Control ENGINEERING

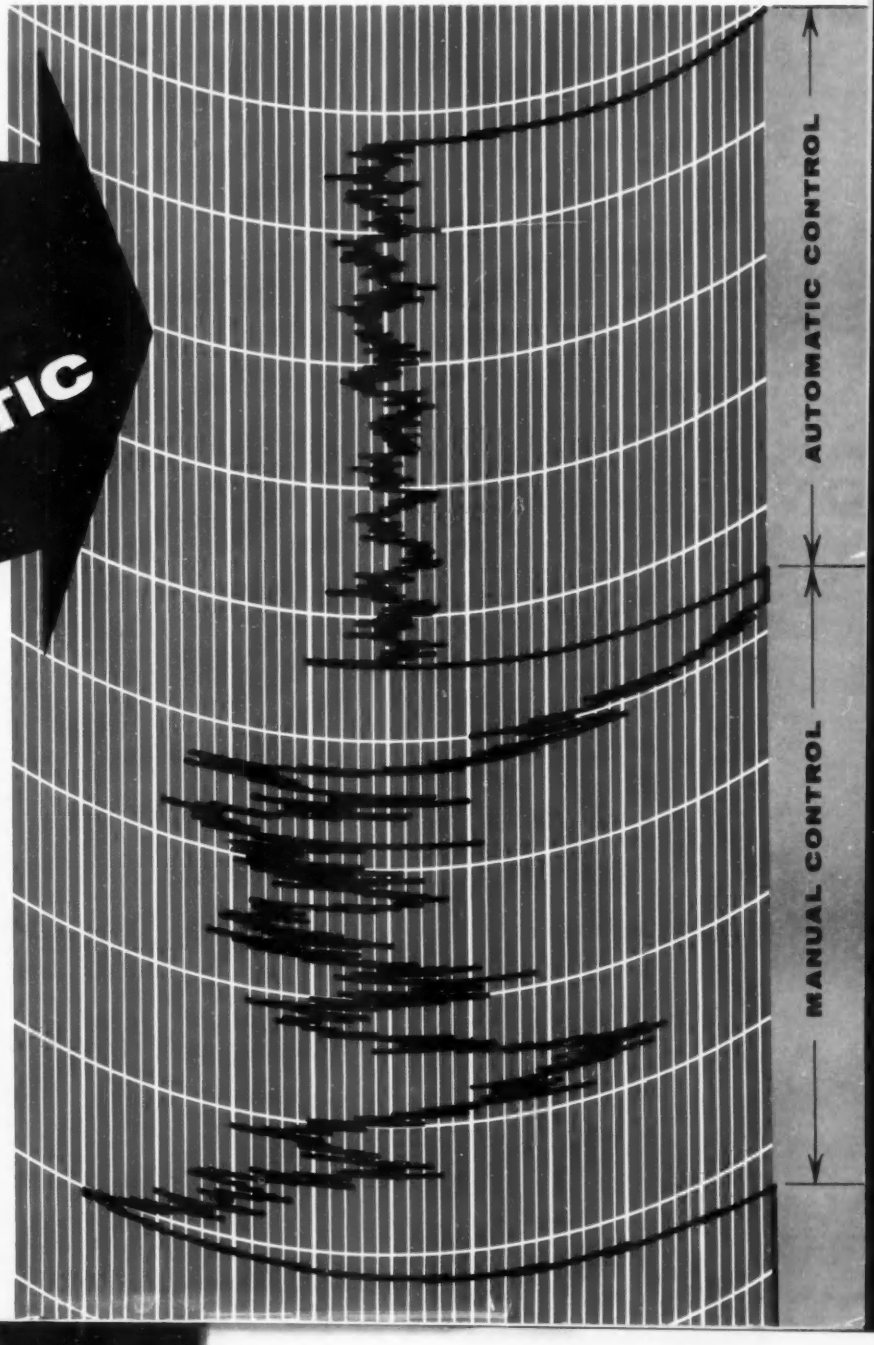
INSTRUMENTATION AND AUTOMATIC CONTROL SYSTEMS

A McGRAW-HILL PUBLICATION

PRICE 50 CENTS

MARCH 1955

CONTROL OF MATERIAL IN MOTION GOES AUTOMATIC



IN THIS ISSUE:

Get Results from New Techniques in Automatic Mill Control

Use Radioactive Instruments— They're Versatile, Noncontacting



Your problem in Electronic Systems Design

A major problem in electronic controls systems design is how to get information into and out of machines, because machines, like people, do not always speak the same language. Thus devices must be created solely to convey information between machines. A good example of this is the Librascope-designed analog-digital converter which translates mechanical motion into electronic codes. Other Librascope devices provide similar avenues of information, making it possible to communicate with machines, processes, and understand heretofore unintelligible phenomena. Librascope components are packaged in sub-assemblies which are then combined into control and data-handling systems for commercial and military projects. These devices can also be assembled into a myriad of different configurations, many of which may be applicable to your particular problems. Write today for details.

Librascope also manufactures mechanical and optical control devices and computers. Send for booklet describing our company.

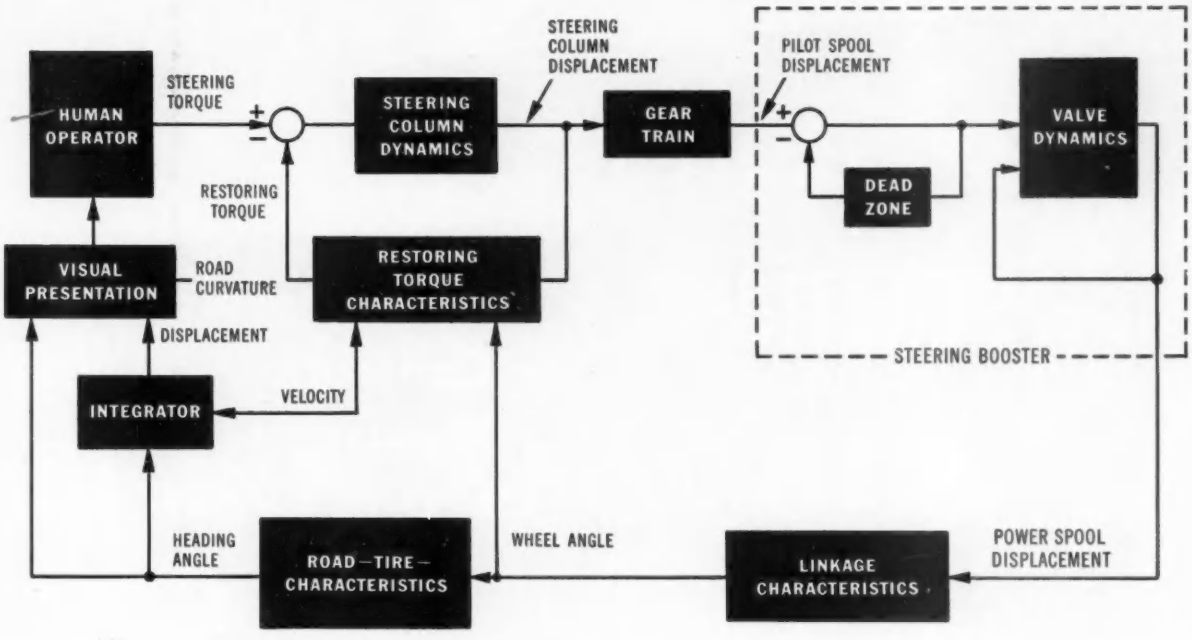


Engineers in search of interesting assignments, security, advancement—contact Mac McKeague, Personnel Director.

LIBRASCOPE

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE, INC. • 808 WESTERN AVENUE • GLENDALE • CALIFORNIA



GEDA *solves control problems*



GEDA
ANALOG COMPUTERS
— best way to give your hunch a chance!

HERE'S A GOOD STEER — for the automotive industry, or ANY industry! Set up any problem, inject your own variables—*and throw away empirical "guesswork"!*

GEDA, versatile analog computing equipment built by Goodyear Aircraft Corporation, facilitates the analysis and solution of difficult control and engineering design problems.

Engineers in a host of industries—including petroleum, steel, chemical, ordnance, electrical and aeronautics—have used GEDA to explore new avenues of approach and solve long-standing "stumpers."

The savings in man-hours and in time-consuming hit-or-miss experimentation, have been spectacular.

The quality and flexibility of GEDA has placed it foremost in its field because of the many interchangeable plug-in computing units available and the unrivaled range of problems that can be readily solved.

The ease of operation makes GEDA a valued partner and vital engineering tool of creative development men—requires no learning of specialized mathematics, delivers results in wave forms and voltages for easy translation into design decision.



Write for FREE Catalog which describes the complete line of GEDA "Advanced Design" Computing Equipment: Goodyear Aircraft Corporation, Dept. 931GC, Akron 15, Ohio.

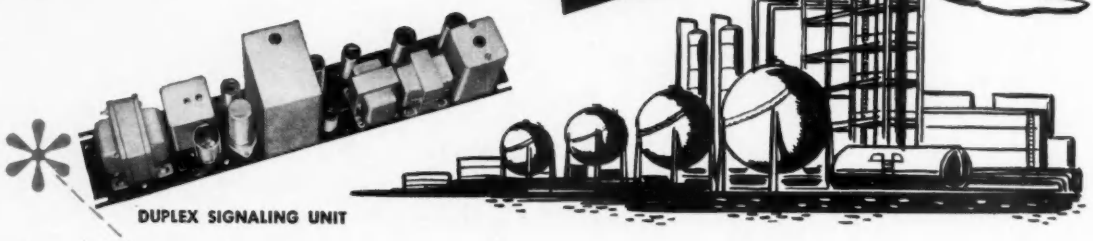
GEDA—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio

GOODYEAR AIRCRAFT

COC
CENTRALIZED OPERATIONS CONTROL...

- Telemetering
- Control
- Report

On One Circuit



DUPLEX SIGNALING UNIT

Centralized Operations Control is the Hammarlund proven method for remote supervisory control and metering of all your plant operations over a single circuit — telephone line, carrier, radio or microwave. All remote operations can be controlled from one or more main offices.

The system can be built into a new plant or used to modernize existing facilities. You can buy a custom-built COC system, open-ended to meet future requirements, or you can build one yourself using Hammarlund components. And, most important, *full use can be made of all existing instruments.*

Our growing list of satisfied customers in the petroleum, chemical, transportation, metal working, public utility and other fields reflects and proves the versatility of COC.

No matter which method you select, you take advantage of the Hammarlund COC building-block components that are engineered and built to give long, dependable, trouble-free service. An example of the type of components built by Hammarlund for COC service is the DSU described below.

For further information on COC, write to The Hammarlund Manufacturing Co., Inc., 460 West 34th Street, New York 1, N. Y. Ask for Bulletin CC-7

* The DSU is an audio tone generator and frequency receiver in a single package unit that transmits and receives signaling, dialing, telemetering, teleprinting, supervisory controls and other information. It operates over wire lines, telephone or power line carrier, and radio or microwave communications circuits.

HAMMARLUND

SINCE 1910

Control ENGINEERING

MARCH 1955

INSTRUMENTATION AND AUTOMATIC CONTROL SYSTEMS

FEATURE ARTICLES

Get Results from New Techniques in Automatic Mill Control — Carl A. Vossberg — 42

Stop Coining Words! — J. J. Brown — 48

Use Radioactive Instruments; They're Versatile Primary Elements — P. J. Stewart and G. J. Leighton — 50

Basic Math with AC Analog Computers — Gareth M. Davidson — 57

Periodicals, Abstracts, Bibliographies for Your Library — Thomas J. Higgins — 67

Compensating Function Pots for Loading Errors — J. Gilbert — 70

How to Analyze Control Systems Graphically—Part 2 — H. M. Paynter — 72

IDEAS AT WORK

Computer Speeds Test-Flight Analysis — A. H. Kuhnel — 81

Ticket Printer Consolidates Loading Records — Vernon Klein — 83

Computer Amplifier Subs for Servo Amplifier — J. H. Hosemann — 85

Telegraph Signals Meter Fluid Level — Ernst Weber — 87

DEPARTMENTS

Control Personality—Gordon Brown — 11

Industry's Pulse—New Products Fare Phenomenally — 37

Editorial—Pull Together — 41

Shoptalk — 4

Feedback — 6

What's New — 12

New Products — 90

Bulletins & Catalogs — 119

Abstracts — 122

Books — 127

Meetings Ahead — 130

WILLIAM E. VANNAH — *Editor*

GEORGE A. W. BOEHM — *Managing Editor*

BYRON K. LEDGERWOOD — *Associate Editor*

LLOYD E. SLATER — *Business Editor*

EDWARD J. KOMPASS — *Assistant Editor*

RAYMOND N. AUGER — *Assistant Editor*

SUSAN RICHMOND — *Editorial Assistant*

JACK GORDON — *Art Director*

DEXTER M. KEEZER — *Dir. Economics Dept.*

G. B. BRYANT, JR. — *Mgr. Washington Bureau*

JOHN WILHELM — *Editor, World News*

GEORGIA MACRIS — *Associate Editor*

Consulting Editors

GORDON S. BROWN — *Cambridge, Mass.*

EUGENE M. GRABBE — *Los Angeles, Calif.*

MARION V. LONG — *Emeryville, Calif.*

DAVID RUBINFIEN — *Chicago, Ill.*

KEITH HENNEY — *New York, N. Y.*

Advertising Sales

R. M. H. BERG — *New York, Boston*

W. F. BUEHL — *Philadelphia, New York*

JOHN C. MITCHELL — *Cleveland, Detroit*

JOHN G. ZISCH — *Chicago, St. Louis*

STOKES T. HENRY — *Atlanta*

JAMES H. CASH — *Dallas*

T. H. CARMODY — *San Francisco*

GORDON L. JONES — *Los Angeles*

W. W. GAREY — *Publisher*

ADVERTISING INDEX 136

PRINT ORDER THIS ISSUE 24,641

ENGINEERED FOR YOU

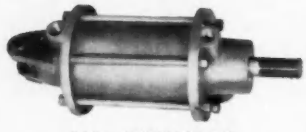
in design...
operation...

Pathon



HYDRAULIC CYLINDER

The design of all Pathon Hydraulic Cylinders in both the R.H. 1000 P.S.I. and QH 1000 P.S.I. Series give you inherent characteristics which result in *compactness, low stress concentration* and *increased fatigue life.*



AIR CYLINDER

All Pathon Air cylinders provide these important interrelated features. *Dual Ram Support, Self Seal Packing, Reduced Power Consumption.* They add up to a better, more efficient operating cylinder for you.



HYDRAULIC DIRECTIONAL CONTROL VALVES

The Pathon H4W series of remotely operated direction control valves are *extremely compact, inexpensive to use, easy to install, efficient in operation* and are designed to complement modern machine design.

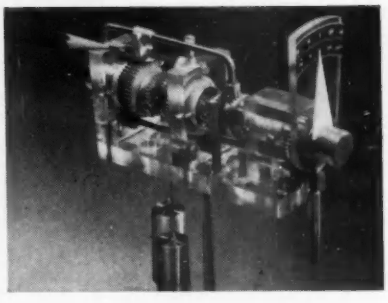
WRITE FOR CATALOG

Pathon
MANUFACTURING CO.
3823 Pacific Ave., Cincinnati, Ohio

SHOPTALK FROM EDITOR TO READER

SURE ENOUGH, HE DID IT

Remember, a couple of months ago we reported that assistant editor Ray Auger was busy building the clockwork torque amplifier he described on page 63 of the January issue? Well, he built it, and here it is. Works fine.



WHAT ABC MEANS TO YOU

Take a look at the hexagonal symbol at the lower right-hand corner of the preceding page. It means that Control Engineering is now a member of the Audit Bureau of Circulations. We qualified by earning our readership through paid subscriptions and passing an exacting audit of our circulation operations. First we want to thank you for helping us win this honor. Also, let us remind you that we are at your mercy. Only if we satisfy you, our readers, can we keep our ABC standing. We wouldn't want it any other way.

MEASURE NOW, FIX IT LATER

The article on mill control by Carl A. Vossberg (page 42), describes a particularly apt solution to a problem that often arises when you control materials in motion. That is, you measure at one point, then apply correction considerably farther along the line. This points up a big role for memory devices in automatic production control.

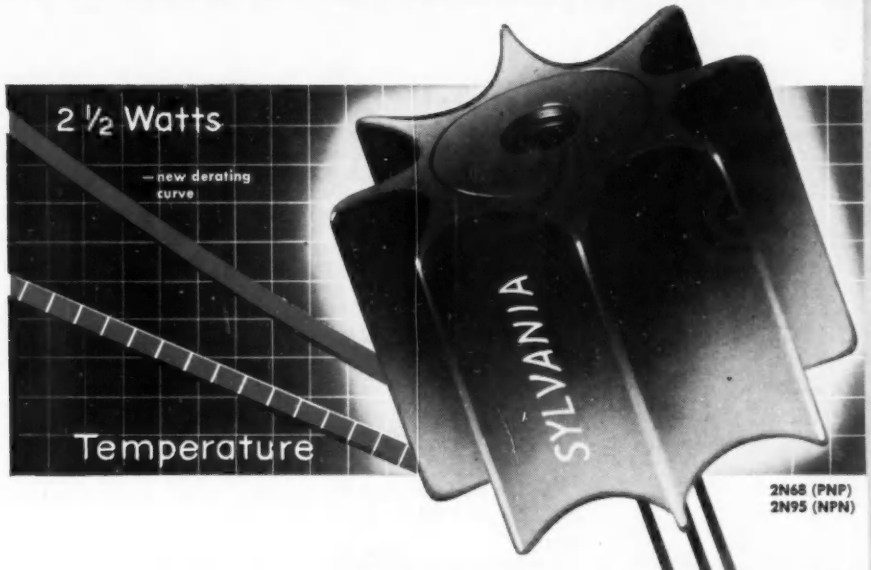
GRAPHIC TYPOGRAPHY CREEPS IN

Not a few of you readers noticed the odd typography on page 35 of the February issue (reproduced here).

Second Program—Valve Position Changes

Graphic though it was, we disclaim credit. In fact, it resulted from a freak accident. Somewhere between the composing room and the press room, the strip of metal that is the top line must have fallen out of the "page" and broken. The man who put it back simply couldn't read backwards, as printers are supposed to do.

Sylvania Power Transistors...



...now with increased ratings

dissipate 2½ watts in free air, have low thermal inertia

NEW Sylvania design developments achieve low thermal inertia and increased ratings in the Sylvania Power Transistors 2N68 and 2N95. Dissipation of 2½ watts in free air reflects a full watt increase over previous ratings. Power dissipation up to 5 watts is possible with an external heat sink.

With Sylvania's new design heat is conducted quickly away from active elements. Resulting low thermal inertia improves performance stability over a wider range of operating temperatures. Operated as a Class A amplifier the 2N68 or 2N95 provides a minimum power gain of 20 db.

"Another reason why it pays to specify Sylvania"

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., University Tower Building, St. Catherine Street, Montreal, P. Q.

Sylvania Transistors — for military, industrial, and commercial applications. Available in commercial quantities.

High-Gain, Low Frequency—2N35 (NPN)—2N34 (PNP)—low to medium power—use as a high-gain audio amplifier—gains up to 40 in grounded emitter circuit.



High-Power, Low Frequency—2N68 (PNP)—2N95 (NPN) increased power ratings—use for high current, low voltage applications (6-24 volts power supplies).

High Frequency—2N94 (NPN)—2N94A (NPN)—high alpha (over 0.95)—low base resistance and collector capacitance—typically 1500 ohms uufd—gains up to 40 db.

Also available in commercial quantities

Silicon Junction Diodes—1N137A—1N138A and allied types—high back resistance at high operating temperatures.

Silicon Point-Contact Diodes—1N193, 1N194, 1N195, 1N196—specifically designed for computer and high temperature general purpose applications. Excellent transient response (0.1 u sec.)



For your semiconductor requirements, check Sylvania first. Use this convenient form to indicate your interests and address it to Department C20R.

Dept. C16R
Sylvania Electric Products Inc.
1740 Broadway, New York 19, N. Y.

Gentlemen: Please forward additional information on the items checked below:

Transistors	*Silicon Diodes*
☐ High Power	☐ Point Contact
☐ High Gain	☐ Junction
☐ High Frequency	

Name_____

Address_____

City_____

Zone_____ State_____

SYLVANIA

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

Giannini
DIGITAL COMMUTATORS

Codes: Binary, Binary-Grey, Binary-Decimal with non-ambiguous outputs



Immediate Delivery from stock on standard models having following characteristics:

- 1,000 counts decimal (300° to 360°)
- 1024 counts—binary, grey (300° to 360°)
- torque—0.5 oz. in ball bearings
- inertia—400 gm. cm^2
- micrometer zero adjustment
- automatic alignment—no gears

CUSTOM COMMUTATORS

Commutators can be furnished to fit specific applications by either modification of standard models or wholly new designs. Some variations now available are:

- non-linear coding
- high-count multi-turn units
- ultra low torque models
- miniature size, geared units
- direct decimal coding

G. M. GIANNINI & CO., INC.
LABORATORY APPARATUS DIVISION
PASADENA 1, CALIFORNIA
Offices: New York: Phone Judson 6-7500
Los Angeles: Phone Ryan 1-7152

Giannini

FEEDBACK FROM READER TO EDITOR

Credit

To the Editor—

Mr. Schultz and I failed to notice that you had deleted, in editing, the following list of references we submitted with the original version of the article "How to Select Governor Parameters with Analog Computors" which appeared in the December 1954 issue. We would like to have them credited.

We had not included derivations of the basic equations with our original draft because of the length, but would be glad to forward them to any of your readers who are interested.

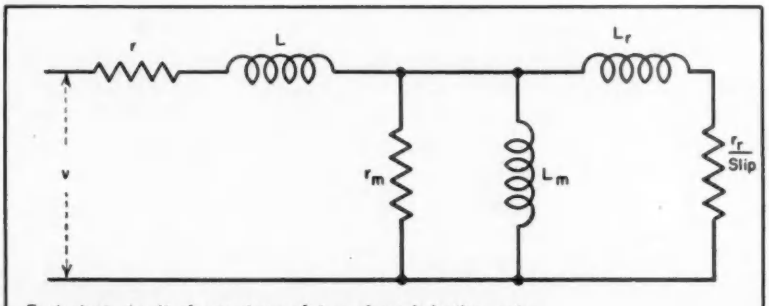
REFERENCES

1. HYDRAULIC TURBINE HANDBOOK, Arnold Pfau; Allis-Chalmers Mfg. Co., 1948.
2. PRINCIPLES OF SERVOMECHANISMS, G. C. Brown, D. P. Campbell; John Wiley & Sons, Inc., New York, 1948.
3. HYDROELECTRIC HANDBOOK, W. P. Creager, J. D. Justin; John Wiley & Sons, Inc., New York, 1950.
4. SERVOMECHANISMS AND REGULATING SYSTEM DESIGN, H. Chestnut, R. W. Mayer; John Wiley & Sons, Inc., New York, Vol. I, 1951.
5. HANDBOOK OF APPLIED HYDRAULICS, C. V. Davis; McGraw-Hill Book Co., Inc., New York, 1952.
6. "The Analog in Governor Design,"

Problem Forum

A group steadily increasing in number beyond 20,000 attends this forum every month. Submit your control engineering problem to their accumulated 150,000 man-hours of experience in all the widespread areas of our field. We offer cash for challenging problems and outstanding solutions.

Readers have deluged the editors with solutions to Problem 3: "How to predict the braking torque of dc on a two-phase servomotor." On page 8 are the two top solutions to the dilemma. As neither solution shows how to derive the braking torque, the submitter of the problem, Sidney A. Davis of Servomechanisms, Inc., will next month present his analysis.



Equivalent circuit of one phase of two-phase induction motor

MARCH 1955 Control Engineering VOL. 2, NO. 3

Published monthly by the McGraw-Hill Publishing Co., Inc. Publication office, 99-129 North Broadway, Albany 1, N. Y. Entered as second class matter at the post office at Albany, N. Y.
Executive, Editorial, and Advertising Offices: McGraw-Hill Building 330 West 42nd Street, New York 36, N. Y. Donald C. McGraw, president; Willard Chevalier, executive vice-president; Joseph A. Gerardi, vice-president and treasurer; John J. Cooke, secretary; Paul Montgomery, executive vice-president, Publications Division. Ralph B. Smith, vice-president and editorial director; Nelson Bond, vice-president and advertising director; J. E. Blackburn, Jr., vice-president and circulation director.
For subscriptions, write to: Control Engineering — Subscription Service, 330 West 42nd Street, New York 36, N. Y. Orders must indicate company and position. Allow one month for change of address. Single copies 50¢. United States and possessions: $3 for one year, $4 for two years, $5 for three years. Canada: $4 for one year, $6 for two years, $8 for three years. Latin America: $10 for one year, $16 for two years, $20 for three years. Other countries: $15 for one year, $25 for two years, $30 for three years. Printed in U.S.A. Copyright 1955 by McGraw-Hill Publishing Co., Inc. All rights reserved.

THE LIGHTNING EMPIRICIST, H. M. Paynter; G. A. Philbrick Researches, Inc., Boston, 1952.

E. C. Koenig
Allis-Chalmers Mfg. Co.
Milwaukee. Wisconsin

Education

TO THE EDITOR—

I have a suggestion for a future article which would discuss the training of control and instrument engineers and scientists with a listing of the various colleges, etc., and the courses they offer with a discussion of the type of instrumentation and control that they emphasize. I believe that some schools lean heavily toward computers while others may be leaning toward control, etc. I have no suggestion as to who could provide this article, but would like to see it in your magazine.

J. G. Lundholm, Jr.
University of North Carolina
Raleigh, North Carolina

John C. Melcher, Chairman of the ISA Education Committee, and W. E. Belcher presented ISA Paper No. 54-10-2, "Collegiate Training in Instrumentation in The United States" at the First International Instrument Congress, Sept. 15, this year. Quoting from the abstract of the paper:

"A statistical summary of [course offerings in the subject matter of instrumentation as described in the catalogs of seventy E.C.P.D. accredited engineering colleges] is presented. Basic measurements of physical quantities is generally well taught. The concepts necessary for adequately understanding the more advanced techniques presently in use do not appear to be widely covered."

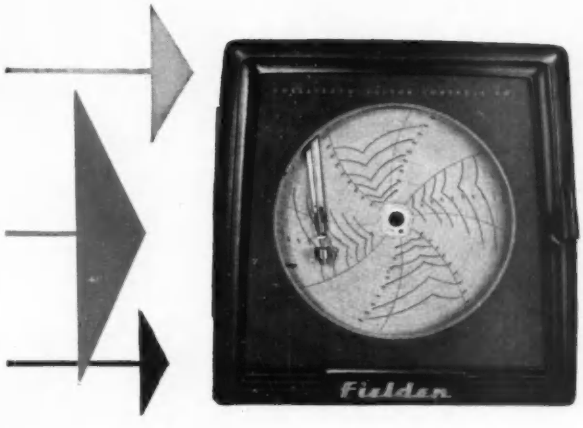
The Committee made its survey by letter. It plans a survey-in-person to evaluate laboratory facilities and teaching aids. Ed.

Unique Sliderule

TO THE EDITOR—

We were one of the recipients of the first issue of CONTROL ENGINEERING, September 1954, and have since become a subscriber. The article on page 85 entitled "Frequency Response Made Easy . . ." evoked considerable interest among our engineers; it describes a slide rule which gives magnitude ratio and phase response angle in one setting, invented by Keisuke Izawa, Assistant Professor at the Tokyo

must ***a well engineered chart recorder be expensive?***



fielden says, "no!" **when you can install a MULTIPOINT Recorder with up to 48 or 96 separate points—with each point available at a cost unheard of before!**

Reason: Simplified design, circuitry, and construction. The chart mechanism is rugged, but so simple in form that there is little or no maintenance throughout the life of the instrument. Yet it's *accurate*—to ±½% of full scale, with a sensitivity of 0.1% and reproducibility of ±0.5%. Fielden furnishes 3 types of Multipoint Recorders: TEKTOLOG electrical quantity for pH, thermocouple and tachometry; A.C. NULL BALANCER for resistance temperature and conductivity measurements; and D.C. NULL BALANCER.

Does simplified, low cost—and reliable instrumentation appeal to you? Then use the coupon below today for full details.



Robertshaw-Fulton
CONTROLS COMPANY



FIELDEN INSTRUMENT DIVISION
2920 N. 4th St., Dept. S, Philadelphia 33, Pa.

Send full details on the Fielden Multipoint Recorders checked below.

☐ **TEKTOLOG Electronic Recorders** ☐ **A.C. NULL BALANCE Recorders**
☐ **D.C. NULL BALANCE Recorders**

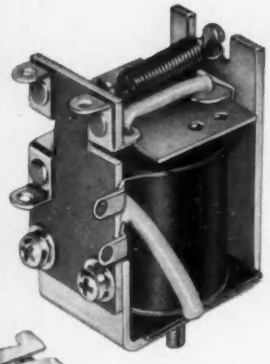
Name_____

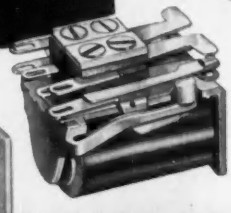
Title_____

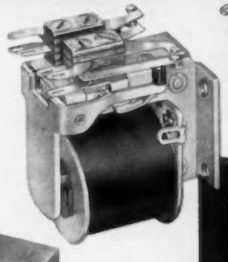
Company_____

Address_____ **City**_____ **State**_____

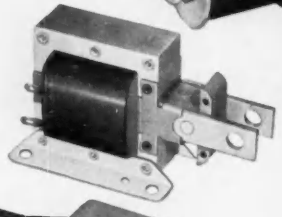
Good products deserve good components

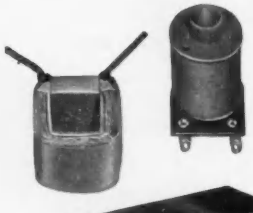




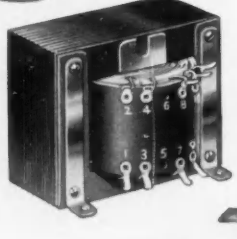


Comar components help good products perform better



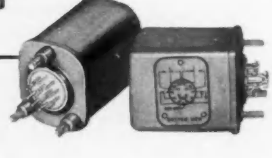


If you use relays, solenoids, coils, transformers, or switches, in your product, your best source is Comar. Custom-manufactured to your specs, Comar components provide maximum efficiency and dependability at low cost. Send for full details now!



Visit Booth 314
The I. R. E. Show





Comar
ELECTRIC COMPANY
3349 ADDISON STREET
CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING

FEEDBACK

Institute of Technology.

If you have information at this time of an American distributor of this slide rule, we would very much appreciate your advising us.

H. H. Clark
Engineering Director
Coleman Engineering Co., Inc.
Los Angeles, Calif.

As this column reported in our December issue, Professor Izawa's slide rule is distributed in this country by Frederick Post Co., 3650 North Avondale Ave., Chicago 18, Ill.–Ed.

The Winning Solutions

TO THE EDITOR—

The assumption that L_m is a complete short on the secondary winding when the applied voltage is direct and that no power will be transmitted to the rotor is correct. However, the implicit assumption that power must be transmitted to the rotor in order to generate a **braking torque is incorrect.** The only requirement which is necessary in order to brake the rotor is to provide a method by which the rotor can transform its kinetic energy of rotation into heat or electrical energy so that it can be removed from the rotor. This is done by producing a constant magnetic field which, by virtue of the rotor rotation, generates a voltage in the short-circuited rotor conductors. The resultant current produces the necessary heat dissipation in the form of an I^2R loss and at the same time reacts with the magnetic field to generate the braking torque. Calculations of torque can be made in much the same manner as for a DC machine.

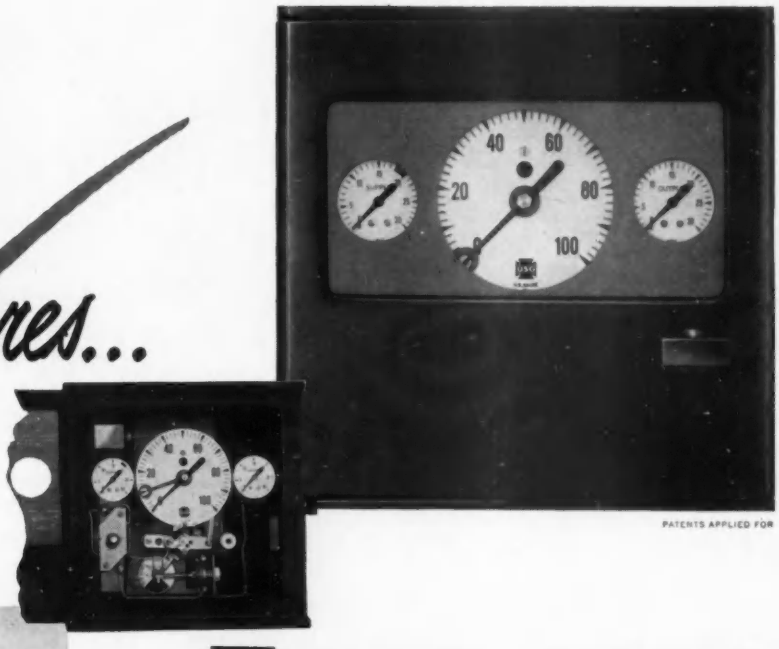
Robert L. Nadeau
Research, Inc.
Dallas, Texas

TO THE EDITOR—

When the AC is removed and the DC applied to a field, the motor looks exactly like a DC motor with a separately-excited field and a shorted armature. The kinetic energy of the rotor is dissipated in I^2R losses in the rotor. The shorted L_m in the equivalent circuit means nothing since no power from the DC source is necessary to stop the rotor. The only DC power necessary would be the I^2R loss in the primary winding. The DC source in effect hands the rotor a means of killing itself but does no dirty work itself.

Michael J. Flanagan,
Robert C. Heimiller
Tonawanda, N. Y.

Check all these features...



PATENTS APPLIED FOR

Only the USG PRESSURE PILOT gives them all to you!

- Embodies precision process gauge, precalibrated and interchangeable. (3½" dial).
- Calibrated set point indicator.
- Screwdriver setting for band adjustment and for selecting desired control action.
- Self-contained Bleed Relay (1¼ CFM capacity) easily adjusted in the field.
- Feedback proportional control or gap action (1-100%).
- Pointer synchronizing adjustment (manual reset).
- Unitized construction.
- Panel or field mounting. (Size—8 9/16" square x 4" deep, including knob.)

Integral process pressure gauge . . . flexible control . . . rugged "unitized" construction . . . manual reset . . . easy selection of control action . . . self-contained bleed relay . . . interchangeable measuring elements . . . simple adjustments . . . modern case styling . . . all the features you need in a pressure pilot—built into a *standard* USG Pressure Pilot.

The USG Pressure Pilot is a major advance in indicating pressure pilots. Incorporating a precision process gauge, it eliminates the need for a separate indicator and provides a direct reading of the set point on a calibrated dial. Exclusive "unitized" construction permits the removal of components and sub-assemblies for maintenance without disturbing the remaining units. The self-contained bleed relay may also be dismantled and cleaned without disturbing its settings.

Simple knob or screwdriver adjustments provide easy set point and control action selection. USG Pressure Pilot also provides 1-100% proportional band or differential gap control with direct or reverse action as required.

Available in ranges from 15 psi to 10,000 psi, the USG Pilot is adaptable to pressure control applications in the process industries. Boiler steam pressure, vacuum relief, pump discharges, fluid pressure and a host of other applications requiring proportional or gap control can be performed by the USG Pressure Pilot—accurately, dependably, economically.

USG is making new advanced design Pressure Pilots available to valve manufacturers. When in the market for valves with pilots be sure to specify that the valves are equipped with USG Pressure Pilots.

UNITED STATES GAUGE

Gauge Headquarters FOR OVER 50 YEARS

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.



Now Fairchild is able to miniaturize potentiometers and still give you the accuracy and reliability you need.

This advance is made possible by Fairchild's continuous and extensive research on new materials such as epoxy-resin and halogenated polyethylene insulating materials, and precious metal alloy resistance wire, and by thorough evaluation of these materials in our own environmental testing facilities. These advances are maintained by our rigid quality control program on materials, processes, and manufacturing.

MINIATURIZATION

without sacrificing performance

Fairchild miniature precision potentiometers meet applicable portions of MIL-E-5272A for humidity, vibration, temperature cycling, fungus resistance and salt spray. These units, in ⅞" and 1⅛" diameters, meet the same requirements for accuracy and reliability as most standard precision units up to 2" in diameter.

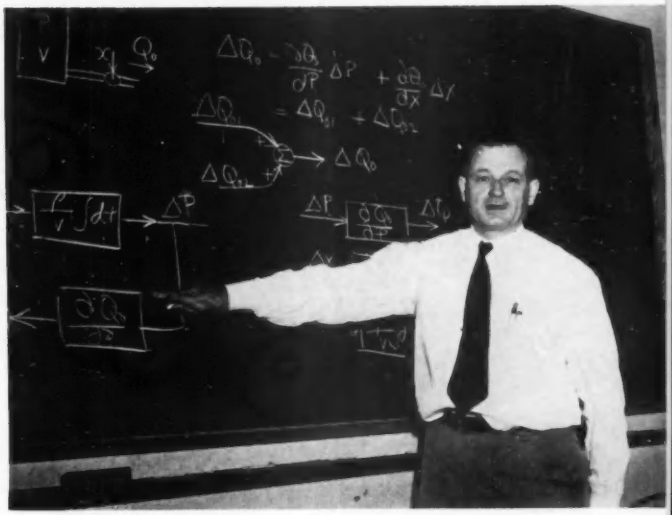
No matter what factors govern your choice of precision potentiometers, you'll find the answer in Fairchild's complete line. Write Dept. 140-59C1, Fairchild Camera and Instrument Corporation, Potentiometer Division, 225 Park Avenue, Hicksville, Long Island, New York.

FAIRCHILD
PRECISION POTENTIOMETERS

A CONTROL PERSONALITY

GORDON BROWN shapes engineering progress

Prof. Arnold Tustin of the University of Birmingham, England, puts the case well: "Already well known to engineers all over the world as a pioneer in the development of automatic control, it may well turn out that Gordon Brown will make a still deeper mark on the engineering development of this century. Two years ago, he became Head of MIT's Electrical Engineering Department. Without completely deserting his old love 'feedback,' he has turned his mind, imagination, and characteristic energy to a radical reconsideration of how the training of electrical engineers can be designed to meet the needs of the future. Already courses are different in type and in content, and the concrete-breakers have reshaped the laboratories. It is a fair measure of his breadth of vision that in this reorganization he is setting in proper relations not only those topics such as control systems and applied electronics that have for many years been his special interest, but that he is intent on filling also the somewhat neglected needs of the power industry."



Gordon is concerned that engineers in all fields understand the importance of, first, considering the mission of an operation and, only then, delving into the dynamics of control. Here he explains the systems approach to compressible flow control.

Gordon moved from down under to the top

Gordon Stanley Brown was born at Drummoyne, New South Wales, Australia on August 30, 1907. After studying at the Melbourne Technical School and serving with the State Electricity Commission of Victoria, he made his way to Cambridge, Mass. There in MIT's Electrical Engineering Department he progressed from bachelor of science to doctor of science, in 1938, and from research assistant to full professor, in 1946.

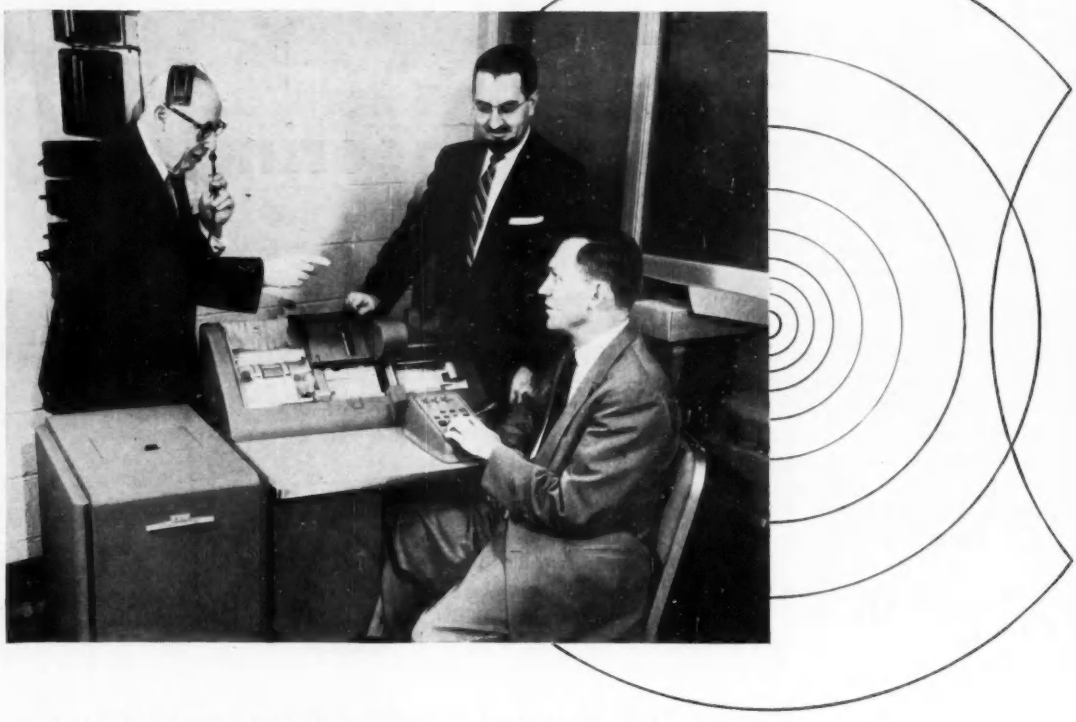
He has been Director of the Servomechanisms Laboratory since its foundation in 1941, when MIT had the only university servomechanisms laboratory in the country. There he and his colleagues undertook an extensive program of research and education for the armed services. They concentrated on developing electric and hydraulic servomechanisms and on increasing the basic knowledge of automatic-control engineering. The educational efforts were crowned by the publication of the book "Principles of Servomechanisms" in 1948. Co-authored by Donald P. Campbell, it is considered the classic text of the field. In recognition of "outstanding services to his country," Dr. Brown was awarded the President's Certificate of Merit, in 1948. And in 1952 he got the Westinghouse Award, given each year to an outstanding engineering educator under 45.

As a laboratory administrator Gordon insisted on budgets, work schedules, and job completion. There was, however, always faith in the simultaneous combination of analysis and experiment that controlled much new thinking. Early realizing that, particularly in designing automatic controls, the engineer must deal with the entire application he was one of the first proponents of the systems engineer.

He never wastes a minute— except on escalators

He is energetic and enthusiastic to the point where he finds it difficult to slow down and to relax. His fondness of eight o'clock classes was viewed with considerable dismay when he taught the original

Continued on page 23



W. P. Westfall of IBM signals Dale R. Cochran of GE to transmit, while Dr. H. R. J. Grosch of G.E. looks on. Data travels over telephone line Westfall is using to get go-ahead from . . .

GE and IBM Weld First Link of Computer Network

Transmitting problems over telephone lines will give engineers and scientists of three plants rapid access to two giant computers. Scheme presages new era in computer service centers.

Imagine a desk-sized computer as fast and as versatile as an IBM 701 or a RemRand Univac. None exist, nor are they likely to for quite a while. But General Electric has installed the next best thing.

The computing center of GE's Aircraft Gas Turbine Div., Evendale, Ohio, has a 701 running three shifts a day. Two other branches of GE funnel problems into this computer—the Medium Steam Turbine, Generator and Gear Dept., Lynn, Mass., and the Large Steam Turbine Generator Dept., Schenectady, N. Y. Up to now they've been telegraphing problems and answers back and forth between Evendale and Lynn, and Evendale and Schenectady. And they've been renting extra time—about one shift a day—on a 701 at IBM's New York headquarters.

The plan is to turn this scramble into a tight network, the first link of which has already been welded between Evendale and New York. The means is IBM's Electronic Data Transceiver (see cuts). This machine transmits data over an ordinary telephone line. It can duplicate punched cards at the rate of 11 per minute.

By this spring, when the system is complete, GE scientists and engineers in any of the three works will be able to funnel their problems to either computer. Besides being fast and automatic, the transceiver ensures greater accuracy than the GE men have been getting by sending their data telegraphically.

The long-range implications of this setup are exciting. Transceiver networks may give smaller companies quick, reliable access to computers which they could not afford to rent or



. . . New York, where IBM president Thomas Watson, Jr., and Allen Keller of GE watch Mrs. Betty Horn hand data on steam turbine design problem to GE vice-president Glenn B. Warren

buy but which they might need for an occasional problem. Or a larger company, with several scattered plants, could rely on one centrally located computer. It all adds up to much more efficient use of a powerful but costly instrument.

The IBM transceivers may soon take on another job not directly linked with giant computers. The U. S. Rubber Co. has just installed two of them—one at its Footwear Distribution Center, Naugatuck, Conn., the other in its New York office. Every night at five o'clock the transceivers start relaying information about the day's business. If this trial works, U. S. Rubber contemplates a nationwide network, linking its nineteen distribution branch points by leased telephone lines that are used for ordinary phone calls during the day.

The transceiver sends its information in the form of "beeps," a pulse code that transmits just as well over telegraph lines or radio channels. And it checks its message to make sure that what is transmitted is the information on the original punched card.

MORE DATA HANDLERS

Univac's New Census Job

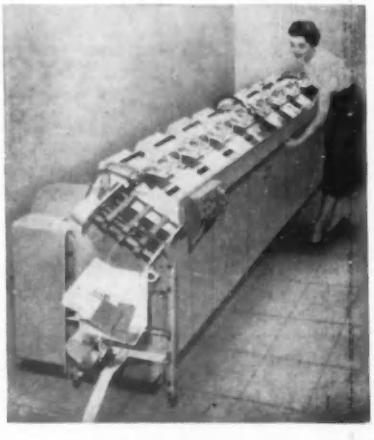
Having cleaned up the dregs of the 1950 population census, the Census Bureau's Univac has now added another task to its repertoire. It is working on the bureau's monthly foreign trade statistics. Once the bugs are worked out, the machine is expected to produce preliminary import and export figures by the 25th of the month following. Final data will be available a couple of weeks later.

Works Like 16 Hands

The lissom young lady bending over the paper assembly line (right) is operating the new Macey Collator. This eight-station machine can gather up to 32,000 sheets of paper per hour and assemble them in sheaves of eight. Machine (without operator) is available from The Macey Co., Cleveland.

Polices Air Traffic

Engineering Research Associates announced a new electronic filing sys-



tem, designed to fit the Common System for Air Traffic Control, which is a nationwide CAA project. The memory, or digital information processor, will store as many as 2,000 flight plans and weather information items on magnetic drums. It can receive and transmit automatically over teletype networks.

ARF Catalogs Recorders

Electrical engineers at the Armour Research Foundation have finished a compilation of available automatic data-recording equipment. The 74-page booklet, prepared under Air Force sponsorship, describes specifications and operation of 70 instruments. Since the field is fluid, it will be revised by January 1956.

Here's a Timepiece That's Aged in Brine

Planning to swim abroad this summer? Wear a Movado watch.

The agency that markets this timepiece recently stowed one of its water-resistant watches in the casing of the Ile de France's steam condenser. After a round trip from Le Havre to New York and back, it was still keeping perfect time. Test or stunt, this briny ordeal must prove something.

Around the Business Loop

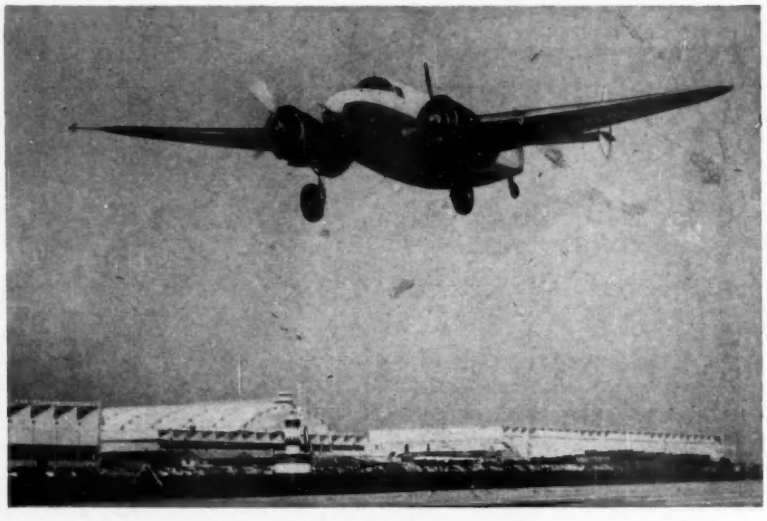
▶ Through an agreement with **Phillips Petroleum Co., Consolidated Engineering Corp.** has added a fresh line of continuous chemical analysis and control instruments. As in most of the big oil companies, Phillips engineers modify and invent equipment to fit their special needs. And some of these homemade instruments and controls have made the commercial grade. Those that Consolidated will now manufacture and market include: infra-red gas analyzers, differential refractometers, ultra-violet analyzers, and oxygen analyzers.

▶ The **Norden-Ketay** merger has been completed by the vote of Norden Laboratories Corp. stockholders. The new Norden-Ketay Corp. is expected to have a volume of $20 million.

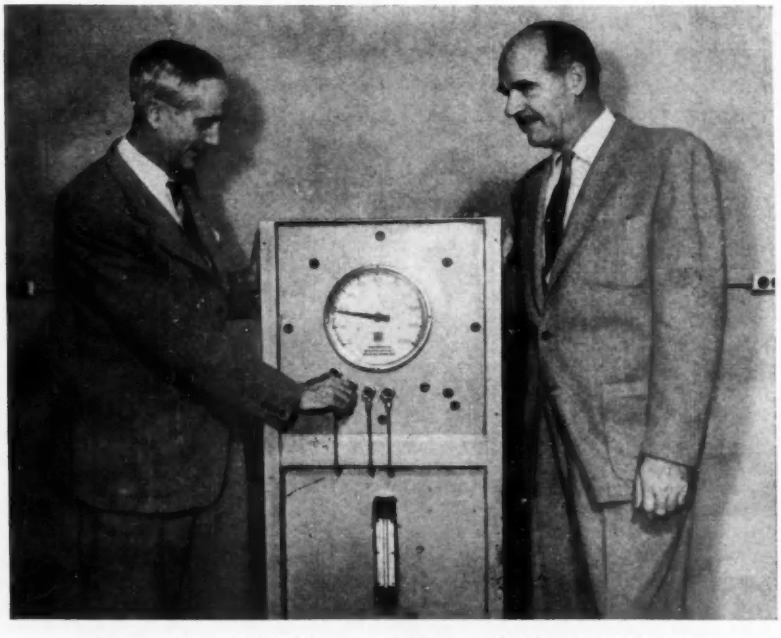
▶ **Reliance Electric & Engineering Co.** has acquired the **Reeves Pulley Co.** The merged companies, with combined assets of about $25 million, will cover the field of variable-speed drives.

▶ **Beckman Instruments, Inc.,** has bought up **Specialized Instruments Corp.** along with the latter's subsidiary **Spinco Service Co.**

▶ **Hamilton Watch Co.** has purchased **Hathaway Instrument Co.** of Denver and is now looking for a 15-acre site in



ONE ENGINE OUT: In a test flight of this new Learstar, the official CAA test pilot (acting as copilot) shut off fuel supply to left engine during take-off run. Lear, Inc.'s, automatic feathering system took care of the dead propeller, and the plane rose successfully on one engine's power.



Vice-presidents R. W. Thomas of Phillips and William D. Nesbit of Consolidated tinker with an automatic differential refractometer

KEPCO

presents a New versatile

VOLTAGE REGULATED Multiple POWER SUPPLY

FOR TRANSISTOR AND ELECTRON TUBE CIRCUITRY

Special Features

- 5651 Reference tube and wire wound precision resistors in divider network for maximum stability
- Precision 10 turn voltage controls
- Supplies isolated from each other
- Rack and bench mounting

KEPCO Voltage Regulated Power Supplies are conservatively rated. The regulation specified for each unit is available under all line and load conditions within the range of the instrument.



Model 450D

OUTPUT	VOLTS	CURRENT	REGULATION	RIPPLE
1	0-150	0-75 ma.	0.1 volts	3 mv.
2	0-150	0-75 ma.	0.1 volts	3 mv.
1 + 2 series	0-300	0-75 ma.	0.1 volts	3 mv.
3	6.3 AC	10 amp.	†	

REGULATION: As shown in table for both line fluctuations from 105-125 volts and load variation from minimum to maximum current.

† AC Voltage unregulated.

RESEARCH • MANUFACTURING
KEPCO Laboratories

30 ADDITIONAL MODELS AVAILABLE FROM STOCK
Complete Catalog on request
WRITE DEPT. 968

KEPCO LABORATORIES

131-38 SANFORD AVENUE • FLUSHING 55, N. Y. • INDEPENDENCE 1-7000

VISIT OUR BOOTHS AT I.R.E. SHOW — #342-344 COMPUTER AVENUE

the Denver area. Hamilton president Arthur B. Sinkler plans to enlarge Hathaway's payroll from 80 to 200. And the new plant may well cost several million dollars. Claude Hathaway will continue as president of the Denver company, which makes precision instruments ranging from gages that measure blood pressure to those that record the dynamic strain on railroad bridges.

▶ In still another corporate shuffle, **Sterling Precision Instrument Corp.** has taken over **Trans-American Precision Instrument Corp.**, which now becomes Sterling's Instrument Div.

▶ In Syracuse, N. Y., **General Electric Co.** held a housewarming in its new 100,000-sq-ft "Systems Center." The two-building center will be GE headquarters for heavy electronic equipment developed and manufactured for the Armed Services.

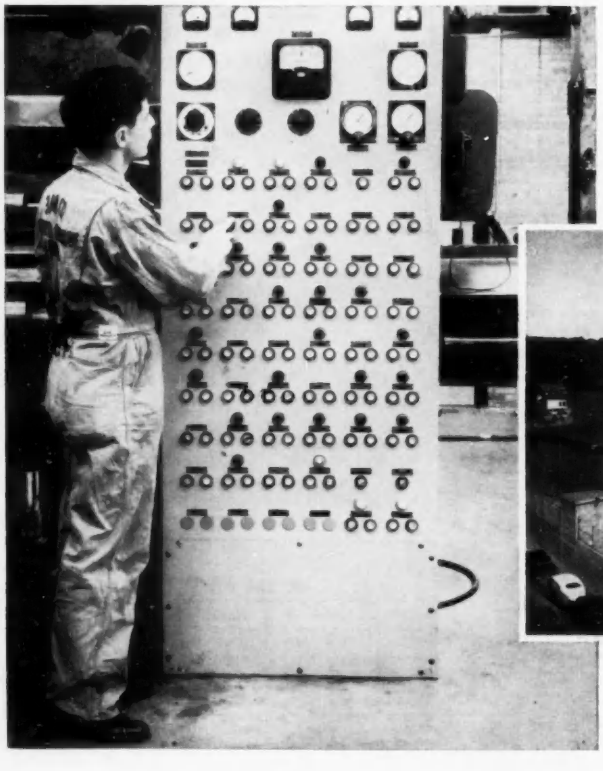
▶ **Avion Instrument Co.** will move within the next year and a half to Riverdale, Md., 7 miles northeast of Washington. The new site—232 acres including an airstrip—is now occupied by the Engineering and Research Div. of ACF Industries, Inc., Avion's parent company.

▶ **Fairchild Camera and Instrument Corp.** is planning a new plant in Los Angeles to house its expanded West Coast potentiometer manufacturing.

▶ Other construction in the L. A. area includes a new building being put up in Pasadena by **Gilco Engineering and Mfg.**, which makes pressure regulators, guidance system components, and fire control valves. And **General Controls Co.** is tacking a two-story, 15,000-sq-ft addition to its Glendale plant.

Where to Learn, Where to Earn

The University of Michigan has announced perhaps the two shortest





The master control panel at the left reigns over MM&M's elongated new plant—claimed to be the world's largest sandpaper maker

Five-Block Factory Fabricates Sandpaper Smoothly

All the talents of control engineering were put to work in scheming out Minnesota Mining & Manufacturing's new continuous-flow sandpaper making process. Electronic, nucleonic, mechanical, and pneumatic techniques were blended in a control system. Some of the specific controls: motor rpm; curing temperature; bond viscosity; nuclear gaging of coating thickness.

A narrow, 976-ft-long plant shell houses the sandpaper maker. Most of this consists of an oven to cure the gravity-and-pipe-fed abrasive and adhesive components on their unfurling paper matrix.

MM&M credits its integrated array of control devices and recorders as prime mover in the unique new operations success. The company believes that besides making the process feasible, the controls provide an inherent flexibility that will speed the commercialization of many lab-bound abrasive innovations.

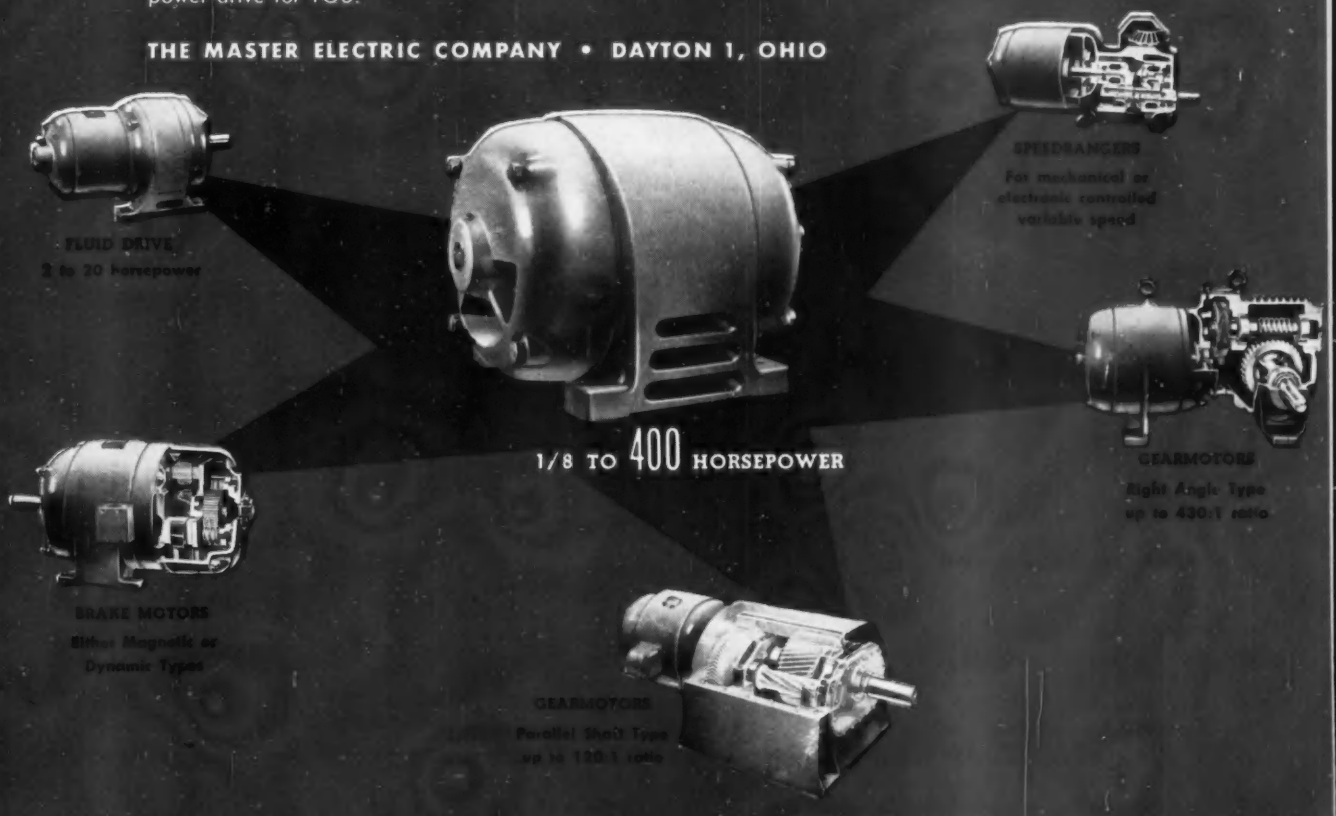
Whenever you select a power unit, don't put a straight-jacket on your ideas . . . consider ALL of the possibilities of modern power drives.

For example consider the many useful combinations that can be secured with the basic Master power units shown below. They're designed so they can be easily combined together to give you the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features in one compact unit that you can use RIGHT where you want it. Nowhere else will you find power units that are so flexible, so easily adaptable, and in such a wide range of types and ratings.

Master power drives are available in thousands and thousands of ratings (1/8 to 400 HP) . . . in open, enclosed, splash proof, fan cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 430 to 1 ratio . . . with electric brakes . . . with fluid-drive . . . with mechanical or electronic variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best power drive for YOU.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

give your brains a chance



automatic control courses on record. The first is scheduled for June 13 to 18, and second for June 20 to 22. Both are meant for engineers who want a basic understanding of the field but can't spend more than a few days. The aim is to present the fundamentals and let the student take with him a comprehensive set of notes that will guide his further study.

April 15 is the closing date for registration. Details can be had from Prof. L. L. Rauch, Room 1521, East Engineering Building, University of Michigan, Ann Arbor.

Decision, Inc., of Cincinnati has just published "Engineers' Job Directory"—a new annual in which companies tell their stories to prospective engineering employees. It is designed primarily to help the young engineer find the job that matches his talents and interests.



Automatic Judge Censors Bad Bearings

The judicial mien of this doughty machine is due to two things other than its control board face. First, it's a native of the Principality of Liechtenstein and, like most continentals, assumes a thoughtful expression when faced with the mechanized splendor of American industry. Second, its name—and function—is "Censor," and this is self-explanatory.

"Censor" classifies rollers and bearing balls down to 0.00002 in. increments and with a maximum error of 1/10 micron. The parts flow to it at random and are automatically mulled over and booted out, if necessary, at speeds as high as 7,000 per hour. And it will route up to 7 matched groups with the same unrelenting precision.

The machine is being imported by Carl Hirschmann Co., of Manhasset, Long Island, N. Y. It certainly packs some unbelievable precision in its 400-lb, 2-by-3-ft frame.

Important Moves By Key People

▶ **Eugene M. Moore** has been named manager of Manning, Maxwell & Moore's new Industrial Control Div., Stratford, Conn. **C. Garland Roper** is chief engineer of the division that will concentrate on MM&M's American-Microsen electronic process control and transmitting instruments.

▶ **H. W. Cory** is promoted to chief engineer of Allis-Chalmers' Hawley Works in Milwaukee. Cory is well known in control engineering circles as chairman of AIEE's Feedback Control Systems Committee. He succeeds T. B. Montgomery, now chief engineer of A-C's industry application section.

▶ **Dr. Gordon K. Teal,** assistant vice-president of Texas Instruments, heads the company's brand new Research Div. He's been specializing in semiconductor research for the Materials and Components Research Dept.

▶ **Armond F. DuFresne** heads a new product engineering department for Consolidated Engineering Corp. Now completing his tenth year with Consolidated, DuFresne has been staff assistant to the vice-president in charge of manufacturing.

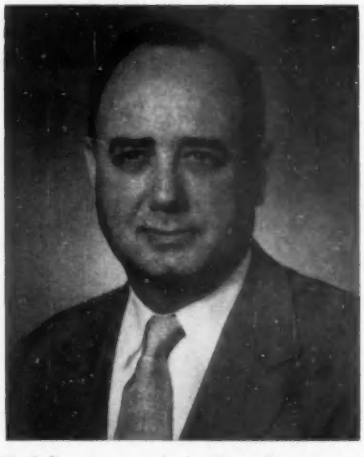
▶ Major changes have taken place at Sperry Gyroscope Co. **Charles M. Green** succeeds **Preston R. Bassett,** who has retired, as president. And **Carl G. Holschuh** becomes executive vice-president and general manager. **Percy Halpert** is engineering director for aeronautical equipment. In the company's new Aeronautical Equipment Div., **Spencer Kellogg** is named engineering manager.

▶ **Otto K. Weltin** has been appointed assistant director of Cook Research Laboratories. **John W. Kelly** is the new chief engineer of the labs' Radar & Communication Section.

▶ Veteran McGraw-Hill editor **Edward S. Cobb** has joined American Machine & Foundry as technical information manager of the public rela-



Moore heads new MM&M control division



Teal directs research for Texas Instruments

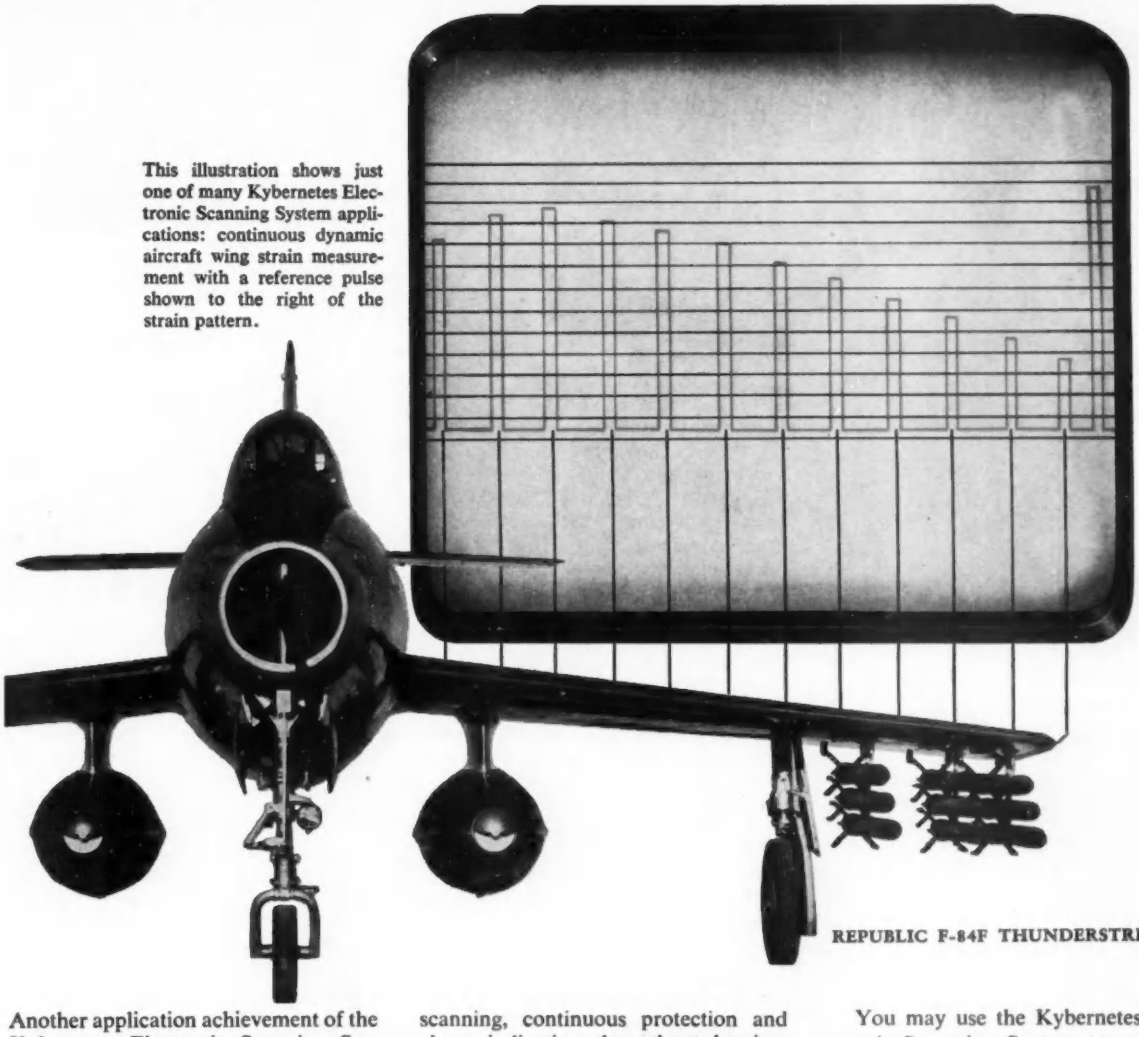


Green succeeds Bassett as Sperry president

PROVEN!

Continuous Dynamic Strain Measurement

This illustration shows just one of many Kybernetes Electronic Scanning System applications: continuous dynamic aircraft wing strain measurement with a reference pulse shown to the right of the strain pattern.



REPUBLIC F-84F THUNDERSTREAK

Another application achievement of the Kybernetes Electronic Scanning System!* This high speed scanning system permits a graphic display of the results of a load test. The strain pattern on an airplane wing appears on the face of an oscilloscope tube as the test is made.

Completely electronic, the Kybernetes Scanning System scans each of any number of points 60 times or more per second. You secure uninterrupted scanning, continuous protection and alarm indication throughout logging, recording, and point reading. There is continuous qualitative and quantitative scope display of any variable. Other readout and alarm devices available if oscilloscope presentation is not desired.

The Kybernetes Electronic Scanning System is readily miniaturized and JANized for airborne and other specialized uses.

You may use the Kybernetes Electronic Scanning System to monitor temperature, flow, level, pressure, viscosity, pH, concentration, conductivity, radiation, gas analysis, as well as for dynamic strain measurement.

For specific information applicable to your own monitoring requirements, write today.

The KYBERNETES Corporation • DIVISION OF SELF WINDING CLOCK CO., INC. (* PATENT PENDING) ©1954
9 EAST 40th STREET, NEW YORK 16, NEW YORK

tions department. Since 1947 Cobb had been an editor of "Product Engineering."

▶ **Clayton L. Foster** is now vice-president of The Austin Co. He retains his post as manager of the Special Devices Div.

Radio Engineers Name Officers

At its January meeting the Institute of Radio Engineers board of directors filled six posts. Reappointments included: W. R. G. Baker, General Electric vice-president of electronics, as IRE treasurer; Haraden Pratt to his 13th term as secretary; and John R. Pierce of Bell Telephone Laboratories, as editor.

Named to the board were: Alfred N. Goldsmith, IRE editor emeritus; A. V. Loughren, research director of Hazeltine Corp.; and Howard Vollum, president of Tektronix, Inc.

According to latest estimates, 40,000 will attend the 1955 IRE National Convention in New York, March 21-24. A program of 55 technical sessions and 704 exhibits will be focused at the Waldorf-Astoria Hotel and the Kingsbridge Armory.

Tape-Controlled Machine Out-Embroiders Grandma

Data-processing experts of the AIEE were recently invited to turn their attention to the feminine art of embroidering.

It happened at the annual winter meeting in New York when Louis Casper described a prototype tape-controlled embroidery machine developed by Electrotext Corp. Casper predicted that "telegraphic engineers . . . might profitably extend their normal interest . . . to comprehend the new uses of signals for control of mechanisms in the textile industry."

Electrotext's punch-tape embroiderer is capable of revving up to 500 stitches per needle-minute—the equivalent of who knows how many deft grandmotherly hands. Furthermore the color, direction, and length of each individual stitch is anticipated in the instant between needle flicks.

Casper believes that a dextrous gang of embroidering machines may parallel loom activity in producing over-all patterns and even solid textures of one color.





Wiener and Brown Part Semantic Curtain

Fourscore definitions of the word "automation" and as many different concepts of its impact on society prompted the alert New York Alumni Club of Massachusetts Institute of Technology to call for an explanation from two of their former teachers who certainly ought to know what it's all about.

The 450 engineers who gathered to hear them weren't disappointed. Dr. Gordon Brown, head of the Tech electrical engineering department and considered by many as the dean of feedback science, cleanly sketched the long historical roots of what most people consider "automation" and described how a renascence in thinking was unleashed by the war to bring the art of control to its present technical potential.

Dr. Norbert Wiener, on the other hand, centered his comments on the fascinating effect that "automatization" – he refuses to call it "automation"—has and will have in the "more human use of human beings."

Essentially, Dr. Brown said, wartime work on fire control and other military problems led to a much more profound understanding of the role that feedback plays in automatic control. This understanding has already grown to the point where today's control art is highly sophisticated and imposes an increasing intellectual demand on the people who design and apply it.

"Automation," as Gordon Brown sees it, "is the use of this art to increase production, improve quality, and reduce the amount of human muscle needed in manufacture."

Dr. Wiener developed an exciting analogy in describing the sociological implications of "automatization." He told how digital computing devices, again brought on by the war, suggested very clear counterparts in functioning of the human nervous system and brain mechanism. This led to his work in cybernetics – a study of the machine and human in motor functions. As the study unfurled, it became apparent that the so-called automatic factory could indeed be a reality. This conclusion came almost ten years ago. Unfortunately, he says, sociologists are only beginning to give serious thought to this today.

Apparently, Norbert Wiener's preoccupation with cybernetics still goes on. He disclosed advance news about what he and his colleagues suspect is a basic and vital discovery in brain mechanics. Electro-encephalographic curves he has recently drawn strongly indicate that the brain has a built-in "clocklike" ability that explains the unity of complicated thought-action. He likened this brain-clock, which has a definite pulse output, to the well-timed sweep that places a picture on a TV cathode tube, and to the timer built into the Tech automatic milling machine which lets it resolve three direction signals into one motion. He concluded that this mechanism in the brain suggests that an efficient computer also must have an inherent timing function.

Case No. 64

Kemp Dryer
Assures Accuracy
For Sun Oil Co.



How SUNOCO® guarantees dependable instrument readings 24 hours a day

WHEN the Sunoco Plant at Marcus Hook, Pa., introduced a new process at the beginning of the year, many new instruments were installed. To dry the compressed air operating these instruments and assure accurate readings, Sunoco installed a Kemp Model 300 S Dryer.

Kemp Dryer Entirely Satisfactory

According to Harold Powers, Instrument Supervisor at Sunoco, the Kemp Dryer has been entirely satisfactory in performance. Operating continuously day and night since installation, it has performed according to specifications, has never been saturated, and has required very little attention.

Kemp Dryers for Every Purpose

Kemp offers a variety of dryer models to meet all problems. Designed to dry air to sub-zero dew points at low cost, they are constructed of quality materials and embody the engineering knowledge gained from Kemp's many years of experience. They are available with manual, semi-automatic, or fully automatic tower reactivation. In addition, Kemp will prescribe the proper desiccant for each specific drying job. If you have a problem involving the removal of water from air, gases, or liquids, contact Kemp engineers now.



Accurate readings depend on constant, dependable supply of dry air. Harold Powers, Instrument Supervisor at Sun Oil Company's Marcus Hook plant, is shown reading two of many instruments relying on Kemp-dried air to assure dependable readings.

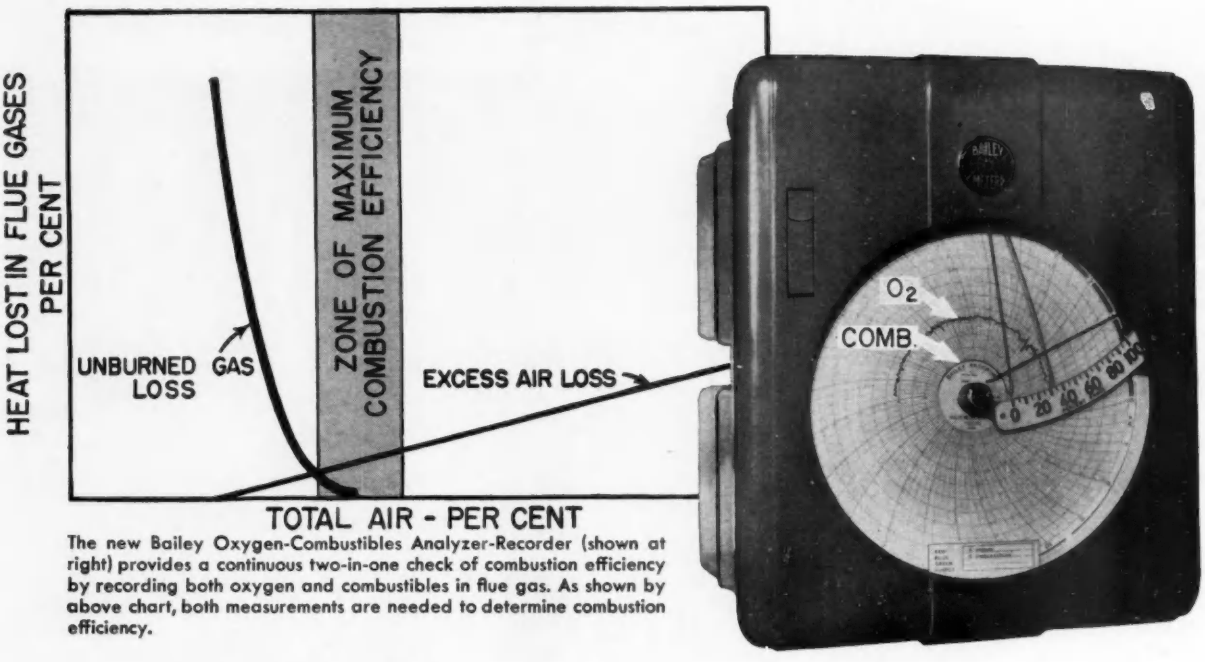
For more complete facts and technical information, write for Bulletin D-27 to:
THE C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

KEMP OF BALTIMORE



DYNAMIC DRYERS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • INERT GAS GENERATORS
SINGEING EQUIPMENT



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces . . . New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. Excess air—regardless of the fuel or combinations of fuels being burned.

2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

BAILEY METER COMPANY

1049 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

For Power And Process

continued from page 11

GORDON BROWN
shapes engineering progress

servo courses. When traveling he is always conscious of the last precious minute allowed for a train or plane connection. While not absentminded, he is one of the few travelers to try to walk down an up-escalator while pondering a ticket at the New York air terminal. On one occasion he got off the New York Central train arriving in Chicago, bustled across to another station and rushed on board a Milwaukee train before most of his companions had taken their bags off the first train.

Some people have thought of this man as a "long-haired" professor. But he has proved his realism in contacts with hard-headed manufacturers. They have willingly put in his hands responsibility for over-all direction of some of their most important projects. A canny business man once asked him point-blank whether he agreed to supply the equipment of a development contract, to meet agreed-upon specifications for the agreed-upon price. His quick answer was that for the price he guaranteed to deliver a complete report of everything that the Servomechanisms Lab did on the project. Beyond this the Lab would do its best to develop the equipment.

There is little doubt that Gordon could be a successful salesman of almost anything. In fact, in his teaching he stresses the importance of salesmanship of ideas. Fortunately for engineers, he has channeled his selling abilities to championing their needs and recognition.

Says Professor Tustin: "I have been privileged to spend a teaching session with Gordon Brown at MIT and to see the dynamics of this process from within. To be an outstanding head of a department with a staff of 600 and with the multiplicity of complex objectives that characterises MIT demands much more than quick scientific insight. It demands the ability to lead, activate, and inspire other people. This Gordon seems naturally to achieve. He does it by good humor, quick understanding, and generous recognition of all the varying contributions to the work of the team. He has faith in youth, and has a remarkable capacity to give his younger colleagues a free rein, confident that their inevitable mistakes and misjudgments will be more than offset by the ultimate development of the initiative and the sound judgment that can only come about as a result of freedom."



PRECISE PERFORMANCE AT A NEW LOW COST
($6.25 ea. in quantities of 1000 or more)
FOR ALL PNEUMATICALLY OPERATED INSTRUMENTS, CONTROLLERS, POSITIONERS AND RECORDERS

The New Kendall Model 55 Air Pressure Regulator provides a uniformly clean, dry, drift-free air supply. It is a "package" unit that combines these features:

- Good flow capacity (up to 15 C.F.M.) plus automatic relief
- Water separation with extremely large dripwell capacity plus pushbutton drain valve
- Adjustable output regulation
- Compact, light, rugged – quality construction throughout

Try the model 55 on your own equipment
– AT OUR EXPENSE

To prove the advantages of the new Model 55, Kendall will furnish equipment manufacturers with one Model 55 at no cost, for test purposes on your own installations. All requests made by individuals on their own company letterheads will be honored but Kendall reserves the right to limit the offer to those having actual applications. Furthermore, the offer may be withdrawn at any time at Kendall's option. Outline your requirements now and send for technical data.

"Engineered Air Regulation"
KENDALL CONTROLS CORP.
144 MOODY ST., WALTHAM 54, MASS.

DC SIGNAL TRANSMISSION

...a vital contribution to complete automation

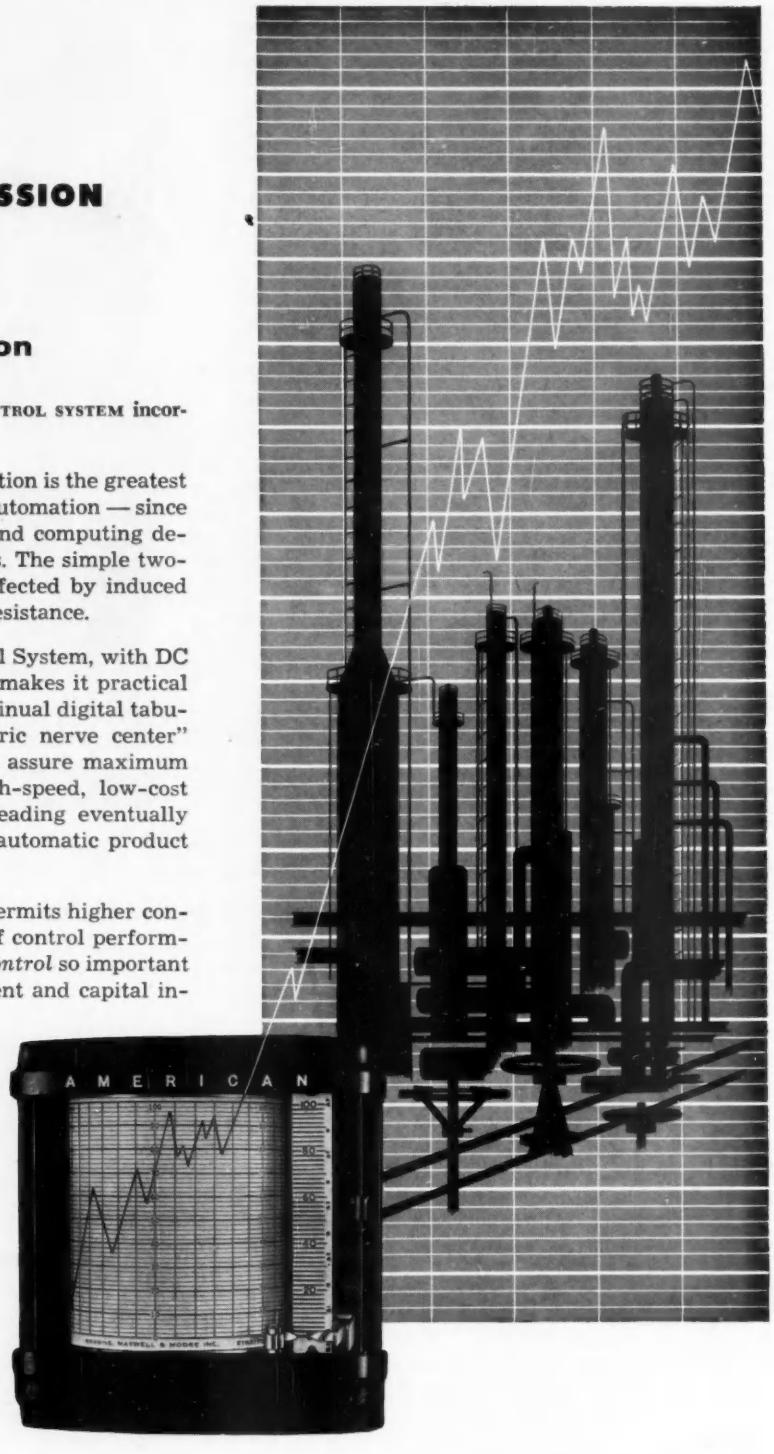
Only the AMERICAN-MICROSEN PROCESS CONTROL SYSTEM incorporates this engineering achievement.

DC TRANSMISSION of process information is the greatest compatability factor for complete automation — since most electronic print-out, monitoring and computing devices use DC in their measuring circuits. The simple two-wire DC communication lines are unaffected by induced alternating currents and varying line resistance.

The American-Microsen Process Control System, with DC transmission of process measurements, makes it practical to use automatic equipment for (1) continual digital tabulation of operational data; (2) "electric nerve center" supervision of all measured criteria to assure maximum safety and efficiency; (3) precise high-speed, low-cost accounting and engineering analysis leading eventually to the ultimate in automation — fully-automatic product analysis and control.

Instantaneous DC signal transmission permits higher controller gains — creates a new concept of control performance. It offers the *improved quality of control* so important in reducing the size of process equipment and capital investment for a given through-put.

The all-encompassing advantages of the American-Microsen Process Control System assure the highest reliability of instrument performance, minimum maintenance and the utmost in flexibility—all vital to the economical operation of the ultra modern plant of today and the standard plant of tomorrow. Your inquiry is invited. Write for Catalog 164.



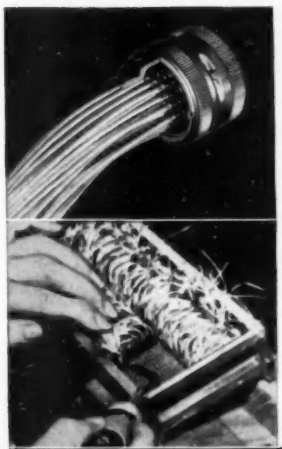
AMERICAN
MICROSEN INDUSTRIAL INSTRUMENTS

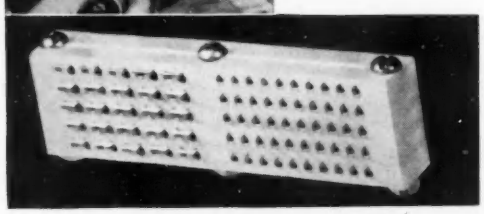
A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONN.

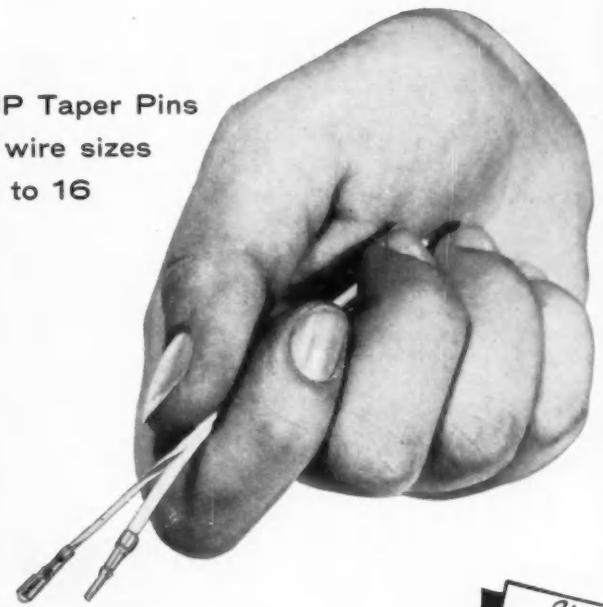
MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

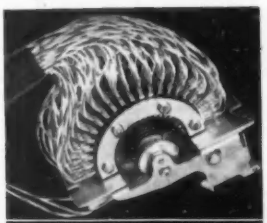
AMP Taper Tab
receptacles for wire
sizes 26 to 18

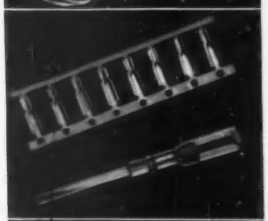
AMP Taper Pins
for wire sizes
26 to 16

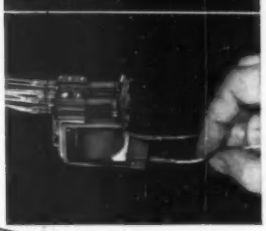












You are cordially invited to visit the AMP booth at the I. R. E. show.
Booths 770 and 772

less cube and cost

WITH ADDED RELIABILITY

Cubic restrictions have brought about a whole new concept of wire termination. The AMP Taper Technique with AMP taper pins, tab receptacles, blocks and modified miniature components will help you take full advantage of small wire, small insulation and small space for your wire terminations.

AMP Trade-Mark Reg. U. S. Pat. Off. © AMP



Another example of AMP's Creative Approach to Better Wiring

AMP

Send today for your copy of our brochure, AMP's Creative Approach to Better Wiring.

AIRCRAFT-MARINE PRODUCTS, INC., 2100 Paxton Street, Harrisburg, Pa.
In Canada: AIRCRAFT-MARINE PRODUCTS OF CANADA, LTD., 1764 Avenue Road, Toronto 12, Ontario, Canada

IDENTICAL AMPLIFIERS IN NEW PRECISION CATHODE-RAY OSCILLOGRAPH

THE DU MONT TYPE 340



- Identical, sensitive X- and Y-amplifiers
- Amplifier response dc to 100 kc
- All potentials regulated for stability
- Hard-tube linear sweeps with beam gate
- Mono-accelerator cathode-ray tube for distortionless presentation

Yes, and also precision, simple operation, ruggedness, reliability, ease of maintenance all characterize the *new* Du Mont Type 340 which can well take its place as the oscillograph for those who require the *best* for their important studies.

Identical amplifiers, unexcelled in other commercial instruments, make the Type 340 a powerful tool for measuring electrical phase or mechanical resonance. Controls can be adjusted for less than 1° relative phase shift between amplifiers below 100 kc. Distortion in amplifiers and sweeps is negligible. D-C stability sets new standards. Shifts in level are scarcely observable, even over long periods of operation. The Type 340 truly fits the needs of the discriminating engineer and scientist.

For further information on the Type 340 write to: Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, New Jersey.

In less than a year you have seen a complete new line of *precision* instruments by Du Mont typified by:

Type 336 CRO	dc to more than 20 mc, high brightness
Type 329 CRO	dc to 10 mc, high voltage
Type 327 CRO	dc to 5 mc, precision calibration
Type 324 CRO	microvolt sensitivity, dc to 300 kc
Type 330	universal electronic switch: dc to 15 mc
Type 300	precision time calibrator

***And* now the Type 340 with identical amplifiers, dc to 100 kc – PRICE $335.00**

TECHNICAL SALES DEPARTMENT
ALLEN B. DU MONT LABORATORIES, INC.,
760 BLOOMFIELD AVE., CLIFTON, N. J.

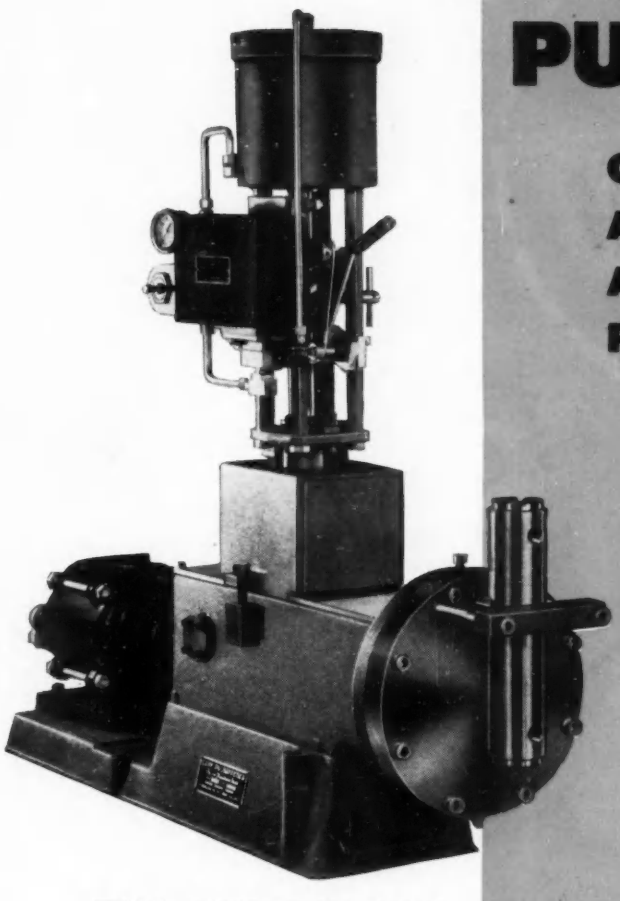
DU MONT

NOW!

Lapp *Auto-Pneumatic* PULSAFEEDER

OPERATES AT FULL CAPACITY AND FULL RATED PRESSURE

The Lapp Auto-Pneumatic Pulsafeeder has made possible automatic continuous processing in many processes involving chemicals or mixtures which have not been satisfactorily handled by pumps of conventional construction. In this construction, pumping rate is controlled by instrument air pressure responsive to variable flow, pH, temperature, liquid level, pressure, or any other instrument-measurable processing variable. And now, new improved Auto-Pneumatic instrumentation provides for greater capacity and/or pressure—full ratings as listed for manually-controlled models.



TWO PUMPS IN ONE!

Lapp Pulsafeeder is the combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only an hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from working pump parts—eliminates need for stuffing box or running seal. Constant pumping speed; variable flow results from variation in piston-stroke length —controlled by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440 with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 391 Wilson St., Le Roy, N.Y.

Another Denison First!



MULTIPUMP

VARIABLE VOLUME VANE PUMP



that gives you variable volume at constant speed

PLUS constant volume at variable speed

Never before has a hydraulic pump offered such flexibility in operation . . . at such savings in operating cost. A revolutionary idea in pump design, Denison MULTIPUMP heralds these new advancements of major benefit to all industry.

NEW, EXCLUSIVE MULTIPUMP PRINCIPLE makes possible great savings in horsepower . . . by delivering only the oil needed by the circuit.

SIMPLE, UNIVERSAL CONTROL is exceptionally flexible in operation...handles requirements of most hydraulic circuits *without additional controls.*

FINGER-TIP CONTROL. Simple hand dial adjusts volume. Volume is maintained by MULTIPUMP regardless of variations in pressure and pump speed.

and in addition...

PRESSURE COMPENSATED, easily adjusted. Can be remotely controlled. Can be vented.

RUGGED, DEPENDABLE. Denison design uses exclusive fully-balanced vane construction.

COMPACT. Takes less space . . . weighs less than other variable volume pumps of equal capacity.

OPERATES COOLER. New Denison design principle circulates oil from tank at all discharge rates, even when pump is compensated.

3 SIZES. Adjustable flow up to:

5 gpm — 15 gpm — 25 gpm at 1200 rpm
7½ gpm — 22½ gpm — 37½ gpm at 1800 rpm
Maximum continuous working pressure...1000 psi



SEND FOR FACTS

Operating characteristics, sizes and capacities of Denison MULTIPUMP are given in Bulletin 190. Write

THE DENISON ENGINEERING COMPANY
1170 Dublin Road • Columbus 16, Ohio
HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics
TRADE MARK

MORE TO COME

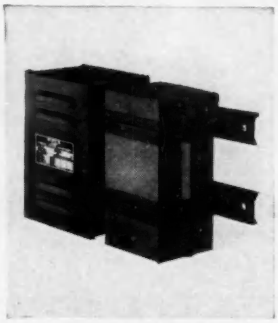
Watch for announcements on other new Denison developments.

A pump for pressures *over* 5000 psi soon to be announced by Denison.





STANDARD TYPE CV
Twenty-nine units from 15va to 10kva in a common power line and filament voltage ratings . . . regulation ±1% or less with a total primary variation of 30% . . . for electronic and electrical equipment requiring close regulation.



HARMONIC-NEUTRALIZED TYPE CVH
Six units from 60va to 2kva . . . input range 95-125v, output 115v . . . all the features of the Standard Type CV plus a harmonic neutralizer circuit . . . ±1% regulated voltage with less than 3% harmonic distortion.



ADJUSTABLE, HARMONIC-NEUTRALIZED TYPE CVL
Two ac voltage supply units, 250va and 500va . . . input range 95-125v, output range adjustable from 0-130v . . . regulated ±1%, harmonic distortion less than 3% . . . for general lab work, testing and other applications.

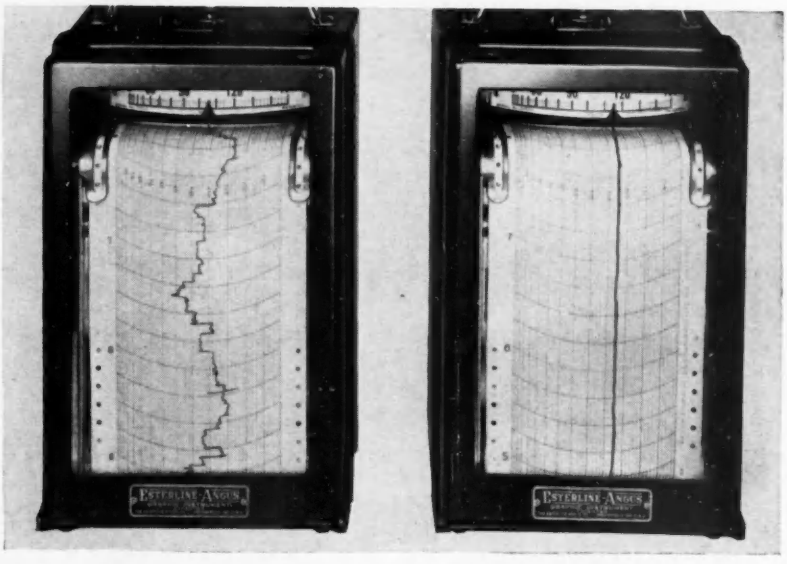


PLATE AND FILAMENT TYPE CVE
Three units in popular power supply ratings . . . a single, compact source of filament and plate supply voltages . . . regulated to within ±3% or less with line voltage variations of 100-130 volts . . . supplied with separate capacitor for chassis mounting.

±1% stable voltage for automatic control equipment regardless of line voltage variations up to 30%

The voltage-critical elements of electronic and electrical equipment for automatic control cannot operate to performance specifications in face of input voltage fluctuations. Stable input voltage can be easily provided with a Sola Constant Voltage Transformer . . . built in as a component, or used externally as an accessory.

Among the chief advantages of Sola regulators are: continuous, automatic regulation . . . response time 1.5 cycles or less . . . no moving or expendable parts . . . immediate availability of 40 stock units . . . and custom units to your specifications in production quantities.



TYPICAL EXAMPLE OF SOLA VOLTAGE REGULATING ACTION. The recording on the left represents a fairly common condition of voltage fluctuation on a 115v line. The chart on the right was made at exactly the same time from the same line. The primary of the Sola regulator was fed the voltage charted on the left, the voltage charted on the right represents its secondary output, regulated to within ±1% of 115v.

SOLA *Constant Voltage* **TRANSFORMERS**

VISIT SOLA'S I.R.E. BOOTH. See the latest in REGULATED DC POWER SUPPLY units. Booth 537, I.R.E. Show, New York, March 21.

CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *BOSTON:* 272 Centre Street, Newton 58, Massachusetts • *NEW YORK 35:* 103 East 125th Street • *LOS ANGELES 26:* 2025 Sunset Boulevard • *PHILADELPHIA:* Commercial Trust Building • *CLEVELAND 15:* 1836 Euclid Avenue • *KANSAS CITY 2, MISSOURI:* 406 West 34th Street • *Representatives in Other Principal Cities*

corridor to Mars?

SANTA MONICA

Flights such as this are, of course, in the future – However, we predict that when the first space flight is made, an American Gyro control system and control components will be used to assure PRECISE CONTROL.

Leading manufacturers of guided missiles, aircraft, target drones, and fire control systems are using the American Gyro "corridor to success" — Why risk a miss, when American Gyro inertial guidance assures a hit?

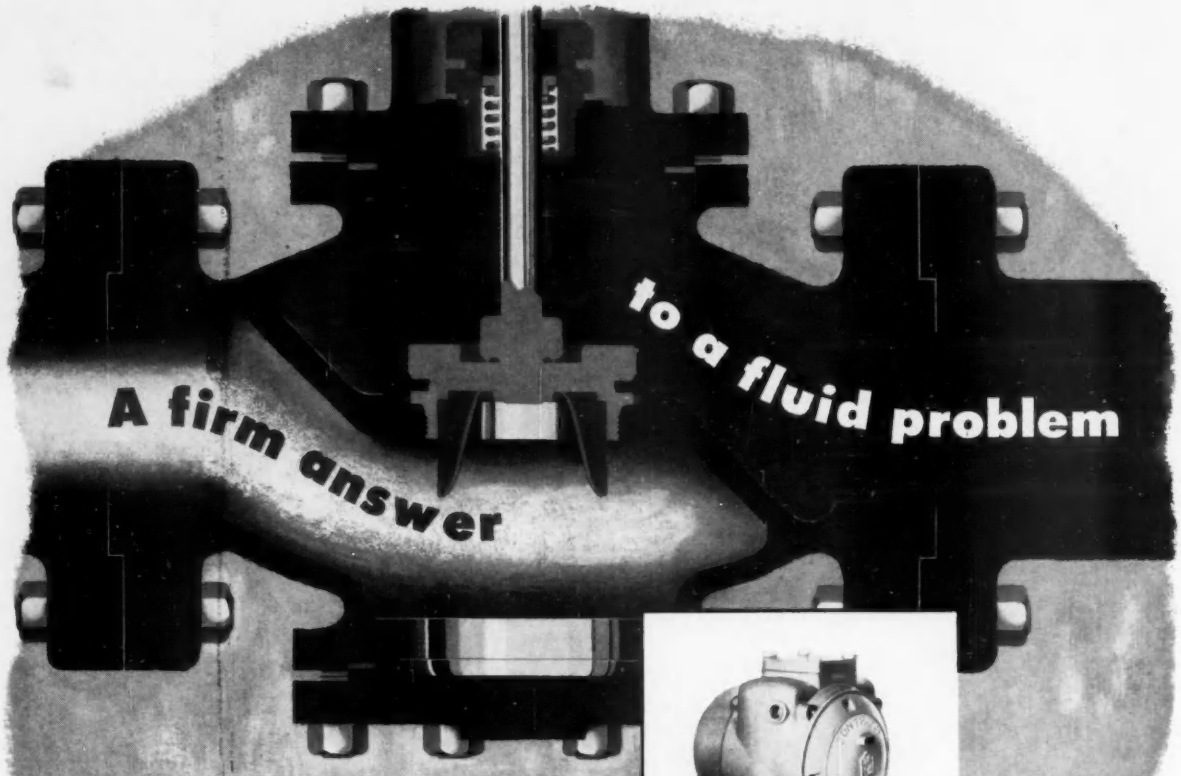
Write for complete details and catalogue!



AMERICAN GYRO
DIVISION OF DAYSTROM PACIFIC CORPORATION
3030 Nebraska Ave. (Dept. 3)
Santa Monica, California

Openings are available for qualified engineers

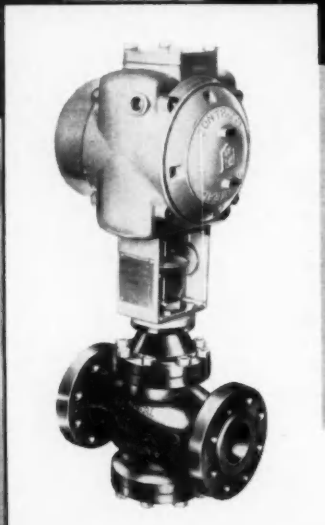
CONTROL SYSTEMS, STABLE PLATFORMS, MINIATURE AND SUB-MINIATURE RATE GYROS, VERTICAL GYROS, FREE AND DIRECTIONAL GYROS, ACCELEROMETERS, INTEGRATION, INTERVALOMETERS, POTENTIOMETERS, SYNCHROS, RESOLVERS, SENSING AND ACTUATING COMPONENTS.



A firm answer to a fluid problem

simple, positive, two-wire control for a wide range of valve applications

Yes, General Controls gives you the answer! *Fast-acting*—because electrical operation assures instant response! *Trouble-free*—because they are electro-hydraulic, with no gear-train problems! *Safe*—because the motor mechanism is in a sealed power unit! *Sure*—because their wide range of valve sizes, materials, and opening-closing speeds will give you the perfect solution to your fluid transfer problems—as they have in thousands of successful control applications throughout the food, process, and oil industries. There's no question—specify General Controls—and you have the right answer!



General Controls *High-Speed* MOTOR OPERATED VALVES

VALVE TYPES	Normally Open and Normally Closed Shut-Off Control.
BODY SIZES	3/8" to 8" ips.
OPERATING PRESSURES	Up to 6000 psi.
BODY STYLES	Globe, Slide Tube, Slide Gate or Saunders; Single or Double Bonneted; Screwed or Flanged Connections.
BODY MATERIALS	Cast Iron, Bronze, Cast Carbon Steel, Stainless Steel.
INTERNAL TRIM	Bronze, Stainless Steel, Chrome Stainless—Teflon and High Temperature Glands.
INNER VALVE TYPES	Quick Opening, Low Lift V-Port, Equal Percentage 100% Drop V-Port, Linear Flow 100% Drop; Port Guided or Stem Guided.
OPERATOR SIZES	H-1, H-2, H-3 and H-5 each with 3 Power Ratings of 60, 90 and 180 VA.
OPERATING SPEEDS	Variable Opening and Closing Speeds from 4 to 161 Seconds.
ELECTRICAL	2-Wire Control, Fail-Safe on Current Interruption; 24, 115, 230 and 460 Volts, 50/60 Cycle AC.
SERVICE	For Water, Steam, Oil, Gas—All Types of Liquids and Gases Including Corrosive Chemicals, High Temperatures and Pressures.
ACCESSORIES	Weather Proof and Explosion Proof Housings, Dust Shields, Limit Switches, Heaters, Manual Operation.

1955 · 25 YEARS · SILVER JUBILEE YEAR

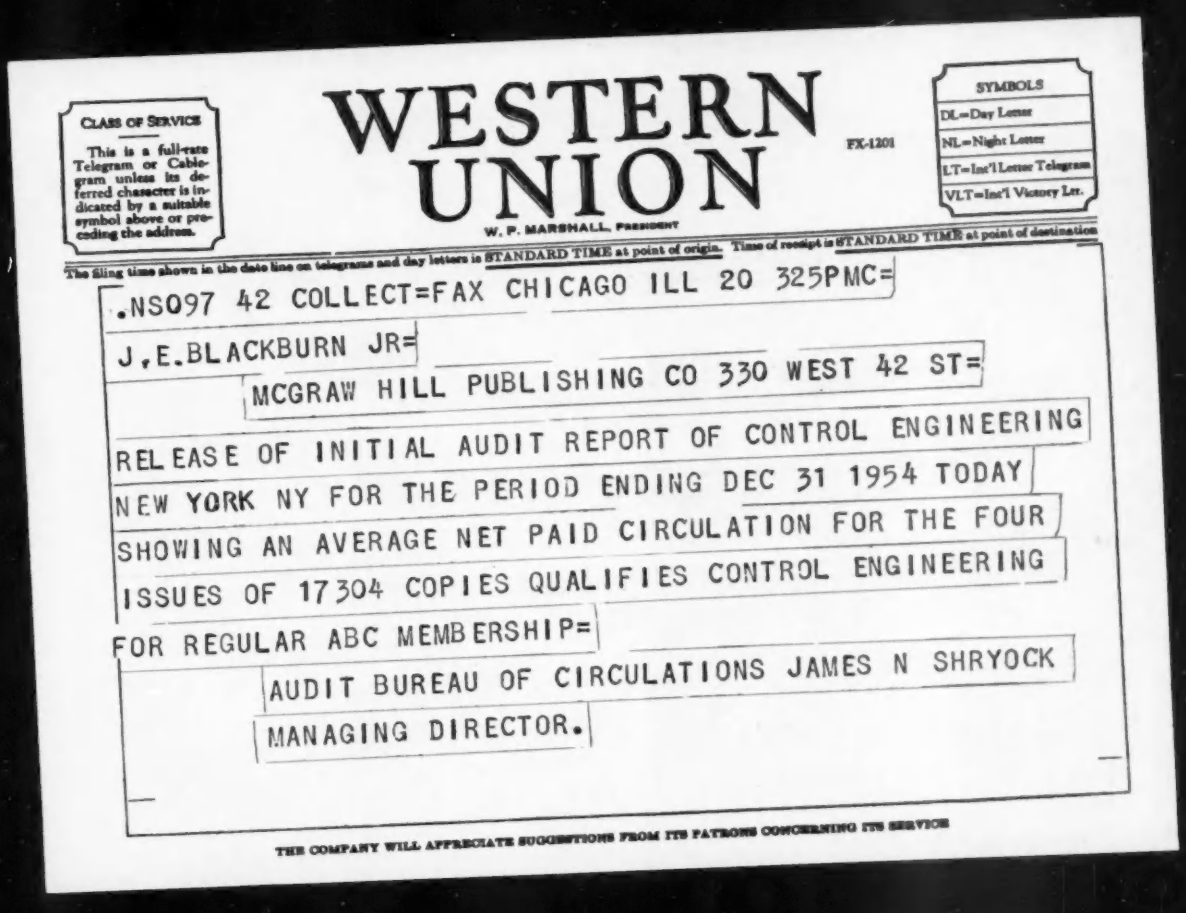
GENERAL CONTROLS

PLANTS: GLENDALE, CAL. · BURBANK, CAL. · SKOKIE, ILL. • 38 BRANCH OFFICES SERVING THE NATION

America's Finest Automatic Controls

MANUFACTURERS OF AUTOMATIC CONTROLS FOR THE HOME, INDUSTRY, AND THE MILITARY

ABC ...in 4 issues



CLASS OF SERVICE

This is a full-rate Telegram or Cablegram unless its deferred character is indicated by a suitable symbol above or preceding the address.

WESTERN UNION

W. P. MARSHALL, PRESIDENT

FX-1201

SYMBOLS

DL=Day Letter
NL=Night Letter
LT=Int'l Letter Telegram
VLT=Int'l Victory Ltr.

The filing time shown in the date line on telegrams and day letters is STANDARD TIME at point of origin. Time of receipt is STANDARD TIME at point of destination

.NS097 42 COLLECT=FAX CHICAGO ILL 20 325PMC=

J.E.BLACKBURN JR=

MCGRAW HILL PUBLISHING CO 330 WEST 42 ST=

RELEASE OF INITIAL AUDIT REPORT OF CONTROL ENGINEERING NEW YORK NY FOR THE PERIOD ENDING DEC 31 1954 TODAY SHOWING AN AVERAGE NET PAID CIRCULATION FOR THE FOUR ISSUES OF 17304 COPIES QUALIFIES CONTROL ENGINEERING FOR REGULAR ABC MEMBERSHIP=

AUDIT BUREAU OF CIRCULATIONS JAMES N SHRYOCK MANAGING DIRECTOR.

THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

Control ENGINEERING

INSTRUMENTATION AND AUTOMATIC CONTROL SYSTEMS

a basic advertising medium for manufacturers of components, instruments, computers, and control devices and systems

ABC

A McGRAW-HILL PUBLICATION, 330 WEST 42ND STREET, NEW YORK 36, NEW YORK

CONTROL ENGINEERING has had a remarkable growth — its planned three year circulation goal was exceeded with the first issue. From its inception CONTROL ENGINEERING has recognized its responsibility to win worthwhile paid subscribers and to submit its paid circulation records for ABC audit at the earliest possible date.

We are proud of our certification by Audit Bureau of Circulations. We are happy to furnish advertisers with further proof of editorial and circulation performance.

You a target?



Let's face it . . . we're all targets!

If your plant is not ready with a disaster plan, better act now. There's not a single American plant that's out of range of an intercontinental bomber—and fires, floods, tornadoes or explosions can kill you just as dead as an atom bomb.

It costs next to nothing to take a few simple steps which may save hundreds of lives. Here they are. Check them off today.

☐ **Call your local** Civil Defense Director. He'll help you set up a plan for your offices and plant—a plan that's safer, because it's integrated with community Civil Defense action.

☐ **Check contents** and locations of first-aid kits. Be sure they're adequate and up to date. Here, again, your CD Director can help. He'll advise you on supplies needed for injuries due to blast, radiation, etc.

☐ **Encourage personnel** to attend Red Cross First-Aid Training Courses. They may save your life.

☐ **Encourage your staff** and your community to have their homes prepared. Run ads in your plant paper, in local newspapers, over TV and radio, on bulletin boards. Your CD Director can show you ads that you can sponsor locally. Set the standard of preparedness in your plant city. There's no better way of building prestige and good community relations—and no greater way of helping America.

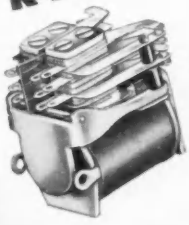
Act now . . . check off these four simple points . . . lives are at stake . . . have you a right to delay?

GUARDIAN®

for single units or complete control assemblies

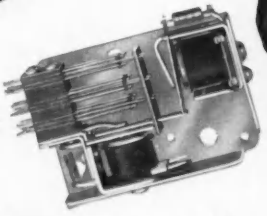
in any combination of electronic parts to your specifications, packaged (hermetically sealed), harnessed, cabled, ready to plug-in...

RELAYS



GUARDIAN Series 595-P Relay

Write FOR RELAY CATALOG 11



GUARDIAN Series 210/120 Relay Interlock

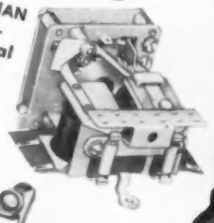


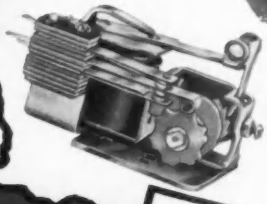
GUARDIAN Hermetically Sealed AN-3312-1 Relay

STEPPERS

Write FOR BULLETIN P-84

GUARDIAN M.E.R. Electrical Reset Stepper

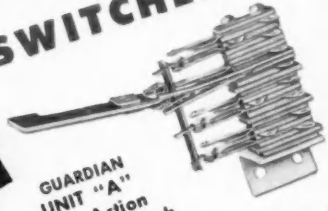




GUARDIAN Series S-120

SWITCHES

Write FOR BULLETIN CS-1



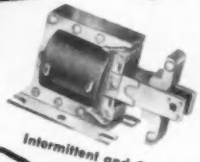
GUARDIAN UNIT "A" Snap-Action Reversing Switch

SOLENOIDS

Write FOR BULLETIN SOL-8



GUARDIAN Series 11 Solenoid



GUARDIAN Series 18 Solenoid

Intermittent and Continuous Duty

CONTACTORS

Write FOR BULLETIN SC-9



GUARDIAN 100 Amp. Sealed



GUARDIAN 200 Amp. NAF-1204-3

for

starting—stopping—timing—counting—computing—sorting—lighting—conveying—interval timing—cycling—selecting—gauging—vending—reversing—add-subtract—radio—radar—armament—power.

VISIT GUARDIAN BOOTHS 582-584 COMPONENTS AVENUE 1955 I. R. E. SHOW

GUARDIAN ELECTRIC

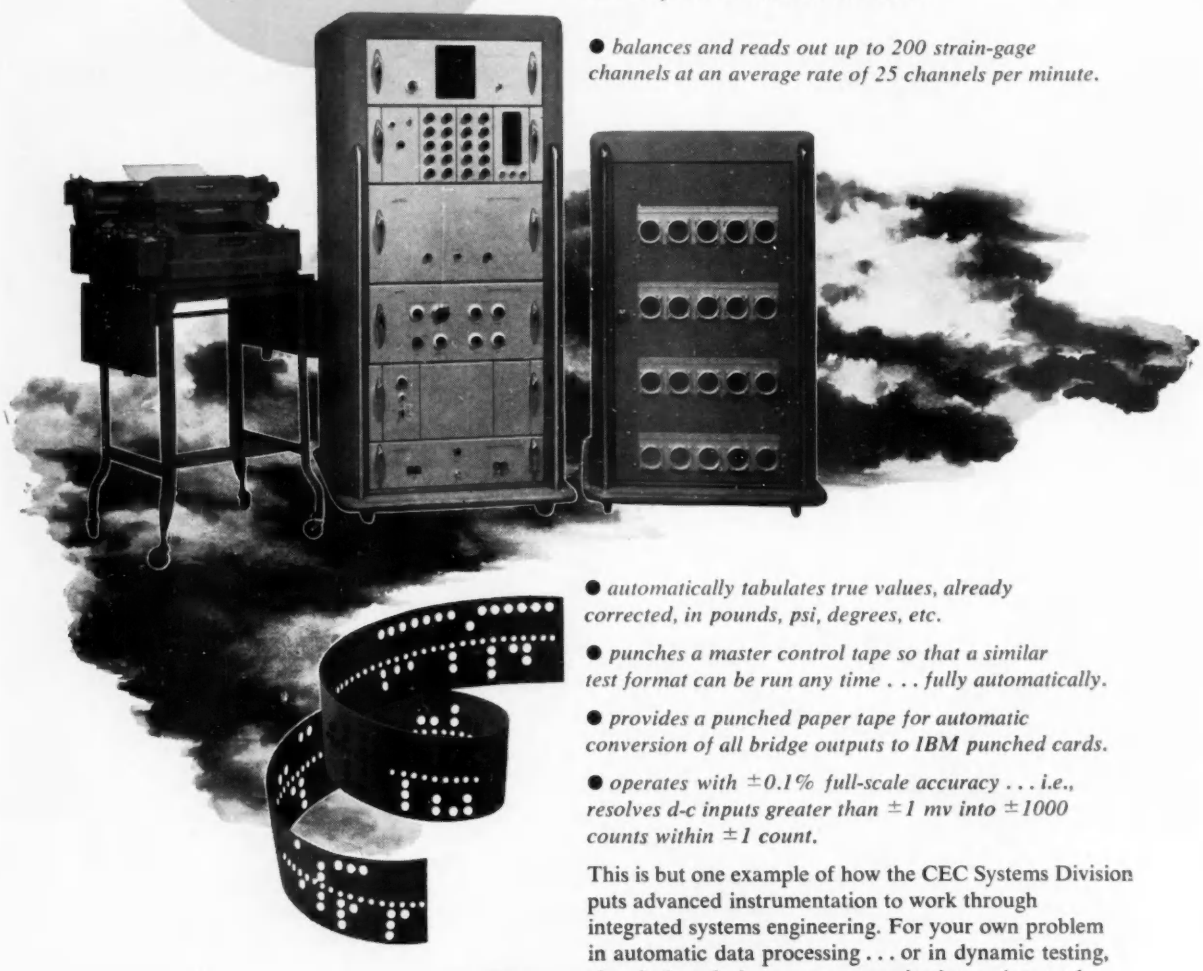
1623-C W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

this, too, is **process control**

Oil refineries and wind tunnels have this in common: both involve a "process" containing three basic ingredients . . . first, a raw material . . . second, operations which change the raw material . . . third, a final product. And both must be controlled. Our job at CEC is to make that control as automatic as possible . . . whether the raw material is crude oil or information.

Recently we built a system (shown below) for automatic control of information at a major aircraft company in Georgia. The "raw material" is a series of electrical signals from test measurements . . . the "product," a tabulation of these measurements in immediately usable, numerical form. Here are just a few of the system's unusual features . . .



- *balances and reads out up to 200 strain-gage channels at an average rate of 25 channels per minute.*
- *automatically tabulates true values, already corrected, in pounds, psi, degrees, etc.*
- *punches a master control tape so that a similar test format can be run any time . . . fully automatically.*
- *provides a punched paper tape for automatic conversion of all bridge outputs to IBM punched cards.*
- *operates with ±0.1% full-scale accuracy . . . i.e., resolves d-c inputs greater than ±1 mv into ±1000 counts within ±1 count.*

This is but one example of how the CEC Systems Division puts advanced instrumentation to work through integrated systems engineering. For your own problem in automatic data processing . . . or in dynamic testing, chemical analysis or process monitoring and control . . . it will pay you to talk to CEC, to learn how *systems engineering* can go to work for you. Send today for Bulletin CEC 1304-X9.

Systems Division

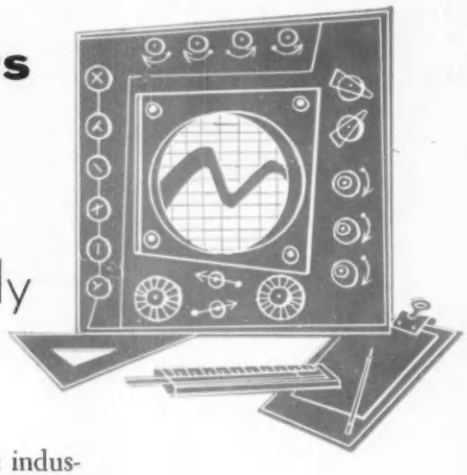
Consolidated Engineering Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service Offices Located in: Albuquerque, Atlanta, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, Seattle, Washington, D.C.

INDUSTRY'S PULSE



New Products Fare Phenomenally

Makers of products for control continue to anticipate industry, confound experts, and swamp editors with their prolificacy.

From our publishing perch we get a sweeping view of new product activity in just about any market. We are frankly amazed by the vitality of instrument and control venders. Our new-products editor wades through more than 200 unique new items each month. Yet, to his frustration, he can write up only about 50 of them.

Control makers show productivity of Solomon

Another thing intrigues us. Many of these new products that pique his imagination look almost too exquisite for the earthy wants of industry. They feature response, sensitivity, and design characteristics that suggest limited use by a precision cult. Yet even the most elaborate gadget seems to find its industrial niche—and, more often than not, a substantial one.

Our belief in control product prolificacy is strongly supported by recent findings of the New Products Institute, Irvington-on-Hudson, N. Y. NPI surveyed 1,130 assorted manufacturers over several years to gage frequency and effect of their new products. Fewer than 10 per cent in this group unveiled something new each year. Most of the companies sprouted at 3-to-5-year intervals.

NPI sees fewer necks out elsewhere

In our checking since last September we find that instrument and control makers are a bunch of eagerer beavers. About 30 per cent of the firms supplying new product releases have already hit us twice in a scant half-year of publishing. And more than half of this group have come up with at least three new products in this time.

NPI's closer look at 200 of its firms suggests that caution may be the restraining philosophy. The fact is that only 19 per cent of new products launched since the war by these firms were, by their own admission, successful.

No parallel tally can be offered for success and failure in control-field products. But we'd hazard the guess that well over one-half make the grade. This is based on the many fresh items we've seen blossom into nuts-and-bolts plant stories—and on the unmitigated enthusiasm of the control engineer for something new.

Control engineers put things to work

Strong testimony to the new-product hunger of the control



NORWOOD CONTROLS Gyro Mass Meter. *To measure true mass flow directly, the flowing stream is sent through a pipe configuration so that the mass of material flowing corresponds to a rotating gyro wheel. When the gyro is precessed by rotating the pipe about the axis of flow, it provides a torque which is directly proportional to the mass flow of the material flowing through the pipe.*

lbs. not gals.

The inherent — and costly — inaccuracies in measuring flow by volume have long been recognized. But could a practical, economical way be found to provide meter accuracy which would be fundamentally independent of temperature, pressure, density and viscosity? The answer is now supplied by the NORWOOD CONTROLS Gyro Mass Meter which measures — or meters — flow by weight, not volume.

With the Gyro Mass Meter, accuracies of measurement are attainable for the first time that meet cost-accounting standards in a variety of continuous flow batching, blending, proportioning, bulk metering and process control applications. Since most of the commerce in bulk fluids is currently transacted on a weight basis, doesn't it make sense to use an instrument that measures *directly* in pounds or tons?

NC NORWOOD CONTROLS

Controls Division
CONTROL ENGINEERING CORPORATION
931 Washington St., Norwood, Mass.

Complete technical information will be supplied upon request

engineer is his feedback to us on Reader Service cards. Our first three issues described 107 new products and these caught the interest of almost 6,500 engineers. Strangely enough, these seekers were very specific in their wants. An average of only 3.5 items were circled per card. Interest ranged, however, quite uniformly over the broad groups of products for control.

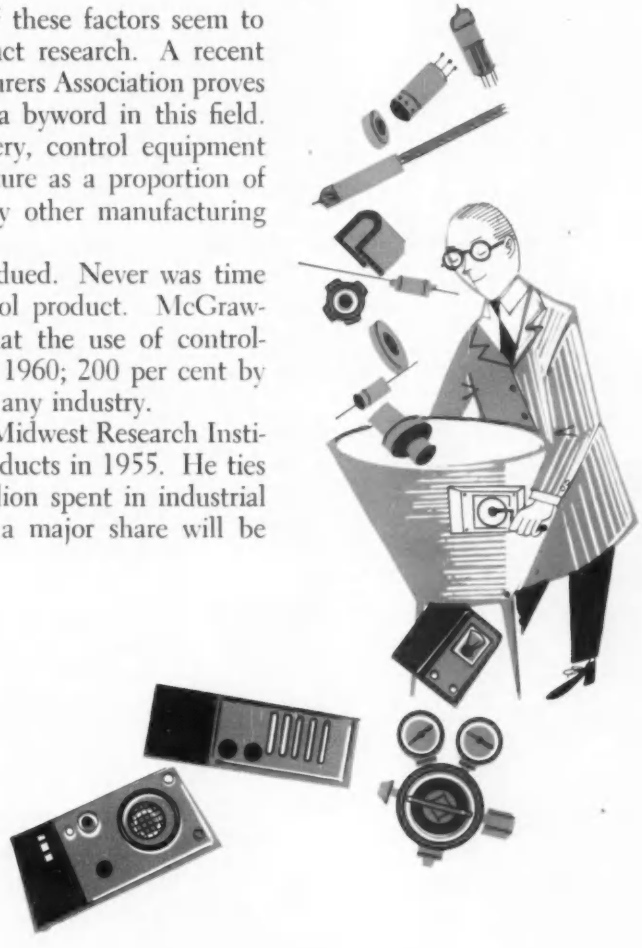
Why do some products fail?

Manufacturers tempted by this voracious market should heed NPI's sobering study of why new products fail. Applying a weighted index to answers, they found that most firms linked product failure to a lack of thorough testing in the field. Other important factors: lack of product research; poor timing; lack of management knowledge of the field.

In the control market at least two of these factors seem to have their fangs removed. Take product research. A recent report by Scientific Apparatus Manufacturers Association proves that thorough product development is a byword in this field. In 1951, along with electrical machinery, control equipment involved 6.4 per cent research expenditure as a proportion of sales—almost 2 per cent more than any other manufacturing industry.

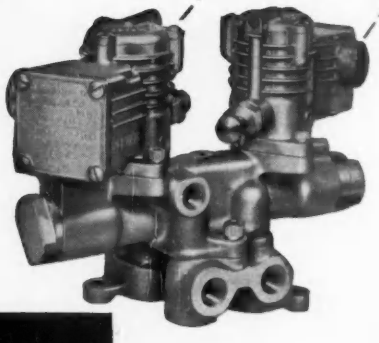
The dragon of timeliness also is subdued. Never was time riper for a new product—if it's a control product. McGraw-Hill's economic projection indicates that the use of control-field products will grow 70 per cent by 1960; 200 per cent by 1970. This is the fastest growth rate of any industry.

Dr. Charles N. Kimball, president of Midwest Research Institute, predicts a bumper crop of new products in 1955. He ties this prediction to the more than $3 billion spent in industrial research last year. We'll predict that a major share will be harvested in the field of control.



DOUBLE

solenoid pilot operated control valve



SPEED KING



Valvair is proud to announce another advancement in the field of automation—The Double Solenoid Speed King Control Valve, designed especially for both the Original Equipment Manufacturer and the End User. This development proves that, more than ever before, Valvair is the name to keep in mind when you order solenoid-operated valves.

Features: Momentary electrical contact—35 to 200 psi pneumatics with internal pilot supply—35 to 150 psi hydraulics with internal pilot supply—Vacuum—300 psi pneumatics and hydraulics using external or remote pilot supply—4-way body—foot or manifold mounting—basic ⅜" and ¾" sizes.

ASK FOR BULLETIN A 12

Valvair

1010 BEARDSLEY AVENUE • AKRON 11, OHIO

Affiliate: Sinclair-Collins Valve Company

Representation in: Baltimore • Birmingham • Boston • Buffalo • Charleston, W. Va. • Chicago • Cleveland • Cranford, N. J. • Dayton • Denver Detroit • Eureka, Calif. • Houston • Kansas City, Mo. • Logansport, Ind. • Louisville • Minneapolis • S. Pasadena • Philadelphia • Pittsburgh Portland • St. Louis • Seattle • San Francisco • Syracuse • Montreal • Toronto • Vancouver

Control
ENGINEERING
MARCH 1955

Let's Pull Together

All over the country engineers have been asking us whether a society of control engineers ought not be organized. Our answer is: not now. The existing engineering societies are beginning to recognize and meet the professional needs of control engineers. And instead of withdrawing to our own corner, we ought to push these societies' efforts to serve us.

Technical meetings this March and April demonstrate that the engineering societies can, through drive and initiative of members, serve control engineers broadly. First the IRE Professional Group on Automatic Control, organized last October, will conduct its first technical sessions March 21 and 22. This group has staked its claim to feedback control, computers, and automatic materials handling in all areas of business and industry. In time, transactions will be published.

Then, ASME's Instrument and Regulators Division will hold its first divisional conference April 25 and 26. This division appreciates the breadth of control system engineering, as you can see by looking at conference papers treating control dynamics of aircraft, exothermic batch chemical reactions, heat exchange, a human operator, nuclear reactors, and electrical power generation.

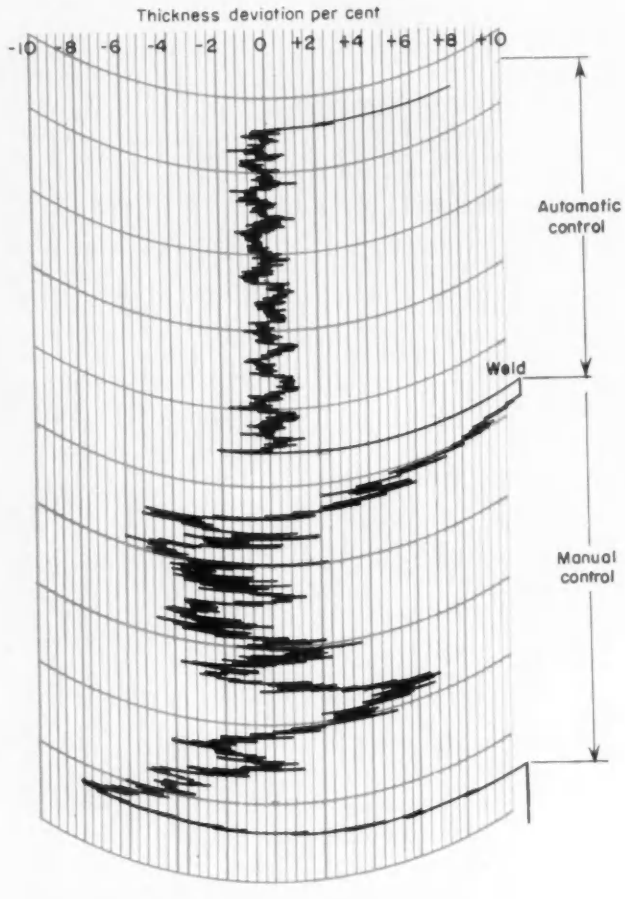
Both groups have virility and broad scope. They are backed by the facilities of their parent engineering societies. They need the support of all control engineers. So, get into these efforts. Keep them broad. Help coordinate their now-separate programs for education and technical meetings.

We see control engineering as a unifying influence. We must not now abandon this concept by withdrawing to set up a separate society. Instead, we must pull together the related professional groups of all the existing engineering societies, not just the IRE's and ASME's.

Only if our concerted and most sincere attempts at coordination fail, should we consider starting a new society.

THE EDITORS

GET RESULTS LIKE THIS



Actual recording of output thickness from a four-stand tandem mill operating at 2,000 ft per min. Strip consisted of two welded coils and was about 8,000 ft long. Notice marked improvement both in transient and steady state after control system was switched on. FIG. 1

BY USING NEW TECHNIQUES IN

Automatic Mill Control

CARL A. VOSSBERG, The Electron Machine Corp.

Improved control systems and increased user acceptance add up to higher rolling-mill speeds, better end products, and increased efficiency of mill operation.

Here's a basic approach to mill control, including the details of an automatic system that will maintain constant-output gage regardless of the transient or steady-state variations in strip thickness.

It is not difficult to appreciate the operator's dilemma in attempting to roll perfect gage on a high-speed multi-stand mill. At 2,500 ft per min the material leaves the last stand less than 2 sec after entering the mill, and at 5,000 or 10,000 ft per min the time in the mill is proportionately reduced. Coupled with speed difficulties are the ever-changing conditions from hard spots, lack of homogeneity of the material, welds, input thickness variations, and the like.

Using conventional controls, with only one output

FROM MILLS LIKE THIS



Typical four-high five-stand tandem cold mill. FIG. 2

thickness measuring element, the material is out of the mill even before it can be measured. Thus the roller can only note a trend and, at best, attempt to correct the oncoming sections by assuming the trend will persist. Should the variations be erratic, or the trend reverse, the thickness can go off-gage in the opposite direction. The "correction" can actually make matters worse. Furthermore, corrections cannot be made indiscriminately. Otherwise interaction disturbs the integrated functions of the mill —loads, speeds and tensions must all be maintained in a proper balance. This is especially true for hot or ductile materials, rolled in a tandem mill.

Therefore a suitable control system must follow the preset commands of the roller to regulate the mill functions within predetermined limits for constant and correct output thickness at the maximum speed and capabilities of the mill. Because of present day restrictions, the system should use existing mill controls.

MILL PERFORMANCE

The elementary mill equations can be set up by referring to Figure 3 (page 46) which shows a web, slab, or strip being compressed by rolls. The volume-rate of material leaving the stand must be equal to the entering volume-rate, or

$$T_o S_o w_o = T_i S_i w_i \qquad (1)$$

where S = speed of web
T = thickness of web
w = width of web

This assumes the material is incompressible.

In most mills the width remains substantially constant, therefore the output thickness is

$$T_o = \frac{T_i S_i}{S_o} \qquad (2)$$

For a given ratio of speeds, the output thickness will vary directly with the input thickness; that is, for an input thickness change of 10 per cent, the output will exhibit the same percentage variation. Thus it would be desirable to feed the mill with uniform material.

Note that the effect of the pressure between the rolls is not included in above equations. Although the thickness is a direct consequence of roll pressure, the final effect is to vary the relative speeds inversely proportional to the thickness.

Similar equations can be formed for a multi-stand mill; for example, see Figure 4.

$$T_o = \frac{T_n S_n}{S_o} \qquad (3)$$

PAST, PRESENT, AND FUTURE

Steel, brass, aluminum, plastics, rubber, and even bake goods require the rolling of sheet material. Hot-rolled steel products alone account for nearly 100,000,000 tons annually. Production on such a scale logically lends itself to the application of control-engineering techniques. But heavy industry has been slow to accept automatic controls, even though they pay for themselves in a very short period.

In 1945 and the following years, automatic thickness controls were installed on brass strip rolling mills. Most were put on single-stand mills, or at least the controls were applied to only one stand. On successful installations an x-ray gage measured the thickness of the strip. This overcame the severe limitations of mechanical contact gages at high rolling speeds. The electrical output of the x-ray gages actuated limit circuits, which operated the mill screwdown controls to correct thickness. To more closely regulate thickness, the screwdown controls were pulsed with proportionately long ON times as the deviations from nominal increased. [For detailed discussion of pulse-time control, see "Use Radioactive Instruments" in this issue.]

In 1950, an automatic-control installation was made on a single-stand steel mill used for precision razor blade stock. The limits for actuation were set as close as 1 per cent of the gage command.

Even with these successful operations, the steel industry has been slow to adopt automatic-control techniques for controlling output gage. User reluctance still dictates that there be no disturbance of the existing parameters and that the transfer to manual operation can be accomplished at any time without deviation from present rolling practice, no matter the inadequacies of such methods.

Thus present mill control systems must still be designed to operate through the conventional manual control equipment. But ultimately, the application of automatic controls will be one of the initial considerations in rolling mill design. They will then be unhampered by the limitations of the present controls and may quite possibly cause basic changes in mill design to obtain better controllability and consequently an improved end product.

Information on the dynamics of steel mill operation is now coming from the analysis and test of installed systems. The future will require the use of these techniques in the design of the complete system, including the rolling mill and the automatic controls.

where T_n = thickness at any section
S_n = corresponding speed

It is assumed that the strip is continuous, has no varying loops, and is operating under steady-state conditions.

In a tandem mill there are several ways to alter the speed ratios, thus controlling the output thickness. Conventional practice places a thickness gage at the output of the mill. No corrections are made until the emerging web at the output deviates sufficiently from nominal to require corrective action. This, of necessity, requires a certain amount of off-gage material to be rolled before any action is taken. The disadvantage of measuring too late, and then noting only a trend, limits the usefulness of this scheme. However, it has been used to control to within 2 per cent of the gage command on slow mills.

In some installations the output thickness is controlled by manually adjusting the input stand speed and observing the overall effect on the output gage. For example, when the output thickness becomes too heavy, the operator slows down stand 1, usually by adjusting its drive motor field excitation. From Equation 3, reducing S_n will reduce the output thickness T_o. This method of thickness control does not develop interactions with the other stands and therefore can be used on high-speed mills. Furthermore, the material at the first stand is heaviest, more ductile, and capable of being subjected to wide tension limits.

High tensions are frequently used on high-speed tandem mills for the cold rolling of steel. This permits some latitude in the mill controls since the mill drive motors' output torques can vary considerably before the sheet loses tension and develops loops. This technique cannot be used on hot mills or in the rolling of ductile materials on tandem mills.

Rolling with tension does have a disadvantage during threading operations and at the tail end of strip when the loss in tension allows the strip to become heavier. With automatic controls, some degree of compensation can be made within the limitations of the mill and its control.

Another method is to regulate the output thickness by varying the last stand speed. Equation 3 indicates the output thickness is inversely proportional to the output speed. It is generally not practicable to vary only the last stand speed because the tensions would vary appreciably and the material is usually thin and hard at this stage. Consequently, the last stand screwdown pressure is simultaneously controlled to maintain reasonable tensions, or none at all, between the last two stands. Because of these interactions, this method is usually applicable only to relatively slow mills.

For ductile materials and hot steel, the problem of controlling the tension between stands becomes complex. Excessive tension will cause neckdowns, cobbles, and strip breakage. In fact, present practice is to not make any changes during the rolling

of such material except to regulate the relative stand speeds for minimum usable tensions. Should the web be off gage, nothing is done until the completion of that particular piece. Then the necessary adjustments to the several stand screw pressures are made with the hope the next piece will come out right. Temperature effects and changes in composition cause variations along the strip. These variations are difficult to "iron" out in subsequent operations. Hot mills are therefore ideally receptive to the use of automatic controls.

NEW CONTROL TECHNIQUES

A typical control system for a multi-stand mill is shown in Figure 6. Each stand is equipped in the conventional manner with the usual screwdown mechanisms, individual driving motors and individual speed controls. This is in accordance with the requirement that the mill must be capable of being operated by normal manual techniques.

The thickness gages are noncontact, high-speed x-ray gages, calibrated by setting the desired nominal gage reading on a dial. The meter, reading plus and minus 10 per cent, indicates deviations of the instantaneous strip thickness about this setting. One gage is between stands 1 and 2, the other at the output of the mill.

Deviation signals from the thickness gages operate trigger circuits whenever the deviation exceeds an adjustable and predetermined limit. In addition, an error-rate circuit is used to determine the rate of change in the error signal. Thus a rapidly increasing error signal produces a correcting command at the controls before the deviation reaches the limit setting.

Gage 1 measures the irregularities of the entering strip. By means of the automatic control system these variations are corrected as much as possible by actuating the screwdown motors on stand 1, using the intelligence derived from the gage. If this operation were perfect and the speed regulation were perfect, the output gaging instrument and the controls on the other stands would need only compensate and correct for drifts, temperature effects, and wear. But, as previously mentioned, the instrument is measuring the thickness after the material has left stand 1. It is too late to make complete corrections. Furthermore, there is a time delay between the detection and the actual movement of the screws. Thus there will be a certain amount of transient off-gage material passing through the mill.

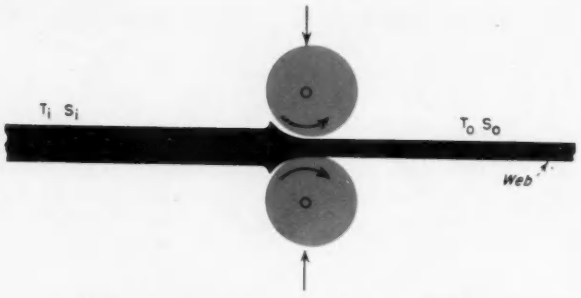
In a tandem mill used for cold rolling steel, frequently two or more coils are welded end-to-end for greater ease in handling. Because of temperature effects in the hot mill, the coils are usually thicker at one end. Therefore, when two coils are welded, the thin section of one coil is butted against the heavy section of the next, Figure 5.

As the coil progresses through the cold mill, the first stand control system will attempt to compensate for this gradual increase in thickness by increasing the screw pressure. But at the weld, the thickness abruptly reverses from heavy to light, and just at the other side of the weld (thin part), the screws settings are completely incorrect and actually aggravating the condition. Without compensation, this can cause strip breakage.

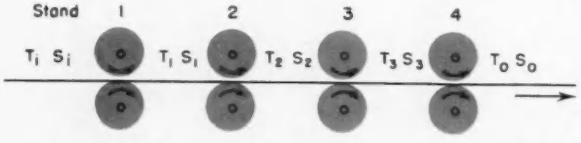
Since the controls on the first stand cannot accomplish complete correction, the information on the off-gage material entering the final three stands is coded on a magnetic storage drum, driven in synchronization with stand 1. Thus the output of gage 1, representing deviations from nominal thickness, is recorded. After the proper time has elapsed so that the off-gage section of the web is at the final stands, the corresponding recorded signal is read off the drum, amplified and transmitted to the computer. The computer operates the speed controller of the last two stands, subject to the commands of the output gage 2 and the recorded signal from the

ROLLING-MILL TALK

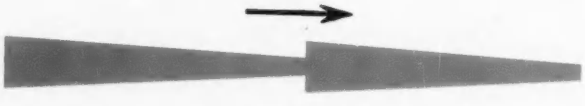
COBBLES—Tangle of steel resulting from a break or other conditions that cause the strip to pile up in heap during the rolling operation.
DRAFT—Reduction in the thickness of the strip by a rolling mill stand. In most steel rolling processes, the draft is related to the elongation of the strip.
LEVELING THE MILL—When the strip cross sectional thickness varies from edge to edge, it becomes necessary to redistribute the pressures between the rolls usually by adjusting the relative forces applied by two screwdown mechanisms on either side of the mill.
ROLLER—The "captain" of the mill rolling crew who directs and is responsible for the overall operation and performance of the mill.
SCREWDOWN CONTROLS—Most mills receive their rolling pressures by means of two rotatable screws bearing directly or indirectly on either end of a movable roll. These screws may be controlled by electrical motors, hydraulic systems, or even hand operated.
TANDEM MILL—A group of rolling mill stands which work in tandem for the successive reduction of the strip to the prescribed gage. These stands are closely grouped so that the material is simultaneously rolled in all stands of the train set.



A pair of rolls compressing a web. Basic steady-state mill equations can be derived from this schematic. FIG. 3



Schematic of multi-stand mill showing thickness and speed before and after each stand. FIG. 4



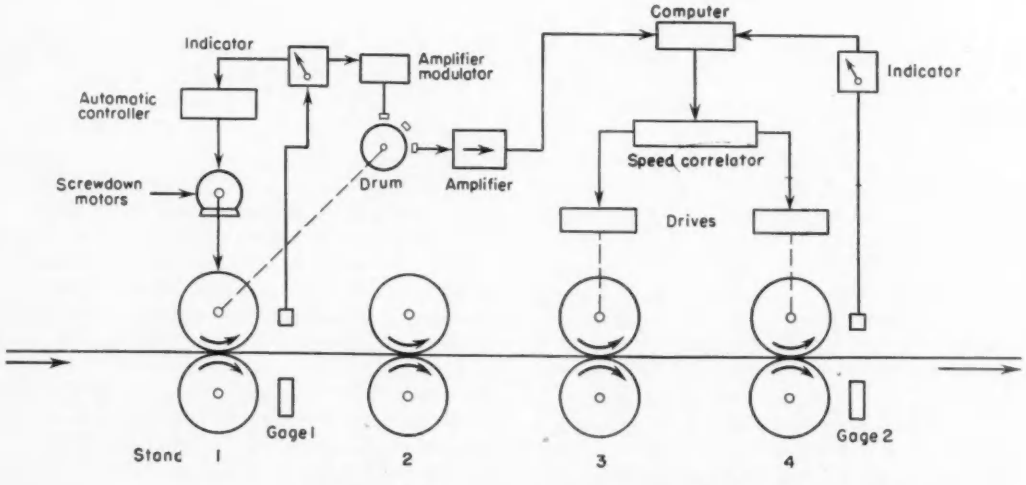
Exaggerated longitudinal section of welded coils. Strip moves in direction shown during rolling, with thickness increasing from beginning to end. FIG. 5

drum. Drum read-out circuitry and read-out heads are adjusted so that the proper signal is available at all times.

Consider the transient developed by the coils welded beginning-to-end. If the first gage and its automatic control system can maintain the correct thickness up to the weld, no corrections will be instigated by the output gage. Then at the weld an excessively thin section will enter the subsequent stands. This information is recorded on the storage drum and in timed relationship will enter the computer, signaling for correction. Stands 3 and 4 immediately slow down, automatically reducing the tensions in an attempt to increase the thickness. This reduction in tension is of practical importance since it permits the weld to pass through without undue stresses. Because of inertia effects, the control can not be instanteous, but the off-gage section is materially shortened.

In operation, slow input thickness variations are handled principally by the input gage and its controller, while variations in the mill will be regulated by the output gage and its controller. In the event of a sudden change in input thickness, the input gage sends an anticipatory corrective signal to the output controller in timed relationship to the web speed. Accordingly, the output web remains substantially unaffected by the abrupt change in input thickness. Transients will be detected principally by the input gage and the anticipatory corrective signal will be of a transient rather than a continuous nature. Continuous supervision of the mill output thickness is assigned to the output gage.

In a typical application, the computer accepts commands from the input controller, applying the



Typical modern automatic control system applied to four-stand mill. Conventional control equipment is included with this system but is not shown on sketch. FIG. 6

necessary correction to the last stands through the speed correlator unless the output gage and controller forbid such operation by demanding the opposite correction. One technique is to incorporate a dead zone of plus-or-minus 1 per cent of thickness deviation, including error-rate effects, in the output system, in which condition the input controller can excite the correcting controls. In other words, if the corrective signals are opposite and the output gage is not indicating a deviation of more than 1 per cent, then the computer will control the last stands in accordance with the input gage command from the drum.

If both request corrections in the same direction, the outputs combine and the corrective measures are increased (longer ON time).

Another method would be to sum the two controlling signals and utilize the net effect for actuating the controls.

Rolling practice frequently allows very little draft on the last stand. In addition, the material may be hard and thin at this point, and therefore adequate control of the thickness is not possible on the last stand alone. With perfect speed regulation (assuming some latitude in tensions), varying the screwdown pressures or the speeds on the inner stands will not affect the final output thickness. Thus the speed correlator regulates the relative speeds of the last two or three stands to maintain the correct output thickness without unduly altering the conditions at the last stand. The operator sets his relative-speed requirements (drafts at respective stands) by adjusting a potentiometer. Conventional field control automatically regulates the stand drives to maintain a balanced output from the tachometer circuits.

Provision can be made also for other control functions, such as constant percentage draft, limits with loads, speeds, or pressures, and including simultaneous screwdown operation.

HOT-MILL CONTROL

For hot-mill application, or ductile material in tandem mills, the overall operation is more complex. Tension indicators or loop detectors are used to determine the condition of the web between stands. Corrections are applied to the screws, and in multistand operation it is preferable to apply corrections proportionately to all the stands.

Consider a hot-steel mill with six stands. In practice the output thickness invariably increases with time because of the cooling of the hot strip. The first gage and its auxiliary control equipment will still indicate transients, while the output gage will monitor the overall mill performance.

Since it is known that the rolled thickness will generally increase along its length, this empirical information can be used to anticipate the need for progressively screwing down on the rolls as the material is being rolled. The two gages monitor the operation and assume command whenever correction is required.

One arrangement is to actuate the screws directly by the automatic systems and to modify the speeds of the affected stands in accordance with the empirical information. In addition, the tension control equipment will also vary stand speed to maintain the proper tensions between stands. Memory devices on each screw reset to the proper original settings at the end of each strip.

In making the necessary corrections to each of the six stands, it isn't sufficient to apply power to each screw motor for a given time. Control and motor characteristics vary. Therefore, each screw is individually modified by the correct preset angle of rotation as commanded by the automatic controller. Manual redistribution of the drafts can be made at any time and as these corrections are not included in the memory storage device, the automatic system will accept the new instructions. The operator can level the mill at any time by adjusting the individual stand screws, independently of the automatic controller.

With automatic control operation, overall mill speed can be varied manually by adjusting the speed of one stand. All others will follow automatically because of the interrelation between stands.

Because of the complex nature of hot-mill automatic control systems, it is impossible to detail their operation in this article. However, it is feasible to automatically control the output thickness and also the width of the strip in a hot-steel mill.

PRODUCT IMPROVEMENT

Figure 1 shows a recording of the output thickness from a relatively fast high-speed cold-steel tandem mill rolling tin plate. Full scale deflection of the recorder corresponds to plus and minus 10 per cent deviation from the nominal thickness. The lower portion is a typical recording for manual control operation, while the upper section shows the improvement with the automatic control system operating. During threading, at welds, beginning of new work order, after a roll change, temperature effects and other unpredictable factors, the thickness is automatically, and continuously controlled permitting the roller to concentrate on the other activities and functions of the mill.

Improvements over manually controlled operation must be expected, but it should be emphasized that the results obtainable with automatic controls will depend largely on the capabilities of the mill and its controls. Results cannot be completely predicted, except that great improvement will apply not only in more on-gage material, better uniformity, greater tonnage, but also in higher mill speeds, less breakage, and fewer cobbles.

These automatic control systems are not intended to displace the roller, but to augment his skill, experience, and knowledge of the peculiarities of the mill and to relieve him of the need for continuously making the minor adjustments required to follow the irregularities of the strip.

Stop Coining Words!

Superfluous words only create confusion, says Mr. Brown, who helped develop the first record-controlled machine tool. A Yale PhD and now one of Canada's most articulate spokesmen for automatic control, Brown works for Aluminium Fiduciaries Ltd., Montreal, the company that handles pension, insurance, and employee stock purchase plans for Aluminium Ltd. There he concentrates on automatic data processing, because he believes it is a good way to demonstrate automatism to management.



Bernard Newman—Scope
Courtesy Fortune Magazine

J. J. BROWN, Aluminium Fiduciaries Ltd.

WE STAND TODAY AT THE BEGINNING of a great new development in technology. This is automatism—control of machinery to bring about fully automatic production of goods and services. For military and economic reasons we should advance in this field as rapidly as possible. Rapid advance in any science is helped by good definitions, clearly understood. These definitions should be existing dictionary definitions, in order that today's writing on the subject may tie in closely with the writings of the past.

Whenever a new subject appears, there is a tendency to coin words. This urge should be suppressed. The automatic production of goods and services is a complex subject, and ill-considered coinages like "automation" only add to the confusion.

The automatic factory is a device capable of producing goods without having any men in series with its machines. It is helpful to think of progress toward the automatic factory as a series of steps. At each step the function of the human being is reduced, first by the arrangement of machines in such a way as to reduce the amount of physical work required, and then later by changes reducing his mental work.

Mechanization

The word for the first step toward automatic production is "mechanization." This word is defined in the New English Dictionary as "the process of making mechanical." The modern transfer machine that performs a series of operations on a rough casting is a highly-mechanized device. So was Arkwright's power loom. Other examples are the wire-making and coining machines common as far back as the 14th century.

At a round table on the subject of automatism sponsored by Fortune Magazine a year ago last June, I tried to make the point that the dictionary already contains a series of words adequate to describe all known forms of automatic control of processes and machines. But I had little success in persuading the industry members of the round table that we already had perfectly good words. Since most of the men writing about the new mechanized plants are from industry, the word "automation" is catching on. This is bad. It is already causing unnecessary confusion which will get worse with the passage of time. Occasionally there is a need for new scientific words, but this isn't one of them.

Automatism

Automatism is the self-control of machines or operations by any means. The key word here is "control." It includes also the supervision of processes as seen in the petrochemical and oil industries. In the dictionary "automatism" is defined as the state or quality of being automatic, and "automatic" means self-acting or self-regulating. A machine is an automaton when it supplies entirely by itself the information needed to keep it running satisfactorily. The basic criterion for judging whether or not a machine is an automaton is to ask what would happen if the man nearest it suddenly has a heart attack and dies. If the machine will go on performing its function exactly the same way and indefinitely, it is an automaton. If, on the other hand, its functioning is in any way connected with the actions of a human operator, it is not. Think of the headlight dimmer on your Cadillac, (an

automaton), and contrast it with the automobile itself (a machine).

Automatism in its most general meaning is what we have when there is a coordination of self-operating machines. Thus in a truly automatic factory there are no men at all in series with the production or transport machines. If in a factory there are any men doing meaningful operations on the production floor, it is not an automatic factory, but a highly-mechanized one.

It is important to insist on the essential difference between mechanization and automatism because the economic, social and design consequences of the two are quite different.

It is true that mechanization, if carried to the point where the last workman is removed from the machines, will turn into automatism. But this is not going to happen. The essential difference between machines and automata is in the question of communication. "How easy is it to tell the device what to do?" If it turns out to be easy, you are dealing with automatism.

Cybernetics

The two key words in this field then are "mechanization" which eliminates some men from the factory floor, and "automatism" which tends to eliminate them all. It would be elegant and tidy if we could go on to make some such generalization as this: "Mechanization is the process of having machines do physical work formerly done by men; automatism is the process of having machines do mental and control operations formerly done by men; automatism is the process of having machines very difficult to sustain. Some highly mechanized devices such as adding machines do away with mental rather than physical work. Some highly automatic devices replace manual labor.

There is, however, a degree of truth in the statement that mechanization has more to do with physical work and automatization with mental work. Mechanization is by far the older of the two processes, and has gone through many more stages of development. Today automatism is taking great forward strides. Devices that show higher and higher capabilities and self-control are beginning to appear. For this reason we are beginning to need a new word to cover those automata in which the control function predominates. The word for this is "cybernetics." For about 25 years French engineers have used the term "l'industrie cybernetique" to describe the branch of automatism that is concerned exclusively with control mechanism. Norbert Wiener of MIT has popularized the term on this continent in three books published since 1948, and it seems to fill a legitimate need.

The objection can be raised that automatism, having been in use long before we knew any methods by which high levels of automatic action might be achieved, carries with it the burden of older meanings. One way to answer this objection is to use "cybernetics" to describe areas of automatism where the emphasis is on the control function rather than on the action itself. The vane of a windmill is a good example, and so is an airplane's automatic pilot. However, automatism has never been a highly popular word, hence its accretions of meaning are slight. The New English Dictionary gives only three examples of its use, all from the 17th and 18th

Continued on page 69

HIERARCHY OF MACHINES

Class	Degree	Characteristic	Examples
Mechanized	Slightly	Mechanical advantage	Block and tackle, automobile jack
	Moderately	Mechanical advantage plus patterned information	Pencil sharpener, packaging and bottling machinery, printing press
	Highly	No overall program. One operation triggers the next.	Automobile, Osborn moulding machine, transfer machines
Automatic, self-operating or self-controlled	Semi-	If anything goes wrong, it rings bell to call operator. Has some kind of program. No feedback.	Auto screw machine, follower lathe, doughnut machine, teletypesetting machine, continuous flow perro-chemicals plant
	Moderately	Has to be set in motion but stops itself. May have feedback.	Vending machines, record changer, digital computers, input and environment control of continuous processing plant
	Fully	Self-starting and stopping at end of cycle. Has feedback.	Headlight dimmer, photocell door opener, MIT milling machine
Cybernetic	Function Oriented	Adjusts itself to changing operating conditions.	RCA driverless automobile, Volscan, automatic pilot, Otis auto elevator
	Product Oriented	Adjusts itself to changes in input materials and resulting product	Automatic digit recognizer, language translation machine, product controlled oven
	Sensitive to environment	Adjusts itself to anticipated changes in conditions.	Minneapolis-Honeywell anticipator, Otis elevator system

Use Radioactive Instruments—

THEY'RE VERSATILE NON CONTACTING PRIMARY ELEMENTS

P. J. STEWART and G. J. LEIGHTON
Isotope Products Ltd.

THE GIST: With the development of nuclear reactors, cheap sources of radioactive material have become available. On these materials are based a whole new range of instruments for industrial measurement and control. As transducers or primary elements, radioactive sensing devices produce an electrical signal proportional to the amount of radiation reflected or absorbed by the measured material. They can determine the thickness of strip material, the resin content of paper, or the density of a liquid in a pipe. The output signal can actuate control equipment or simply indicate a measurement.

All materials will absorb a certain amount of radiation. How much they stop depends on their physical characteristics and dimensions and also upon the type of radiation, Figure 1. The wide variety of instruments in this field arises from the fact that it is possible to pick the type of radiation best suited to a particular type of measurement.

Radioactive materials emit four types of radiation —alpha, beta, and gamma rays and neutrons. These four types differ in penetrating power. Alpha rays consist of heavy particles (two neutrons coupled with two protons), easily stopped by thin foils. Beta rays, which are lighter particles (electrons), will penetrate thicker foils and sheets, but still have a distinctly limited range. Gamma rays on the other hand are a form of "invisible light" electromagnetic radiation (very similar to x-rays). They are not stopped completely by any thickness of material, as are alpha and beta rays, but rather diminish exponentially by passage through matter. One-quarter inch of steel stops all alpha and beta rays, but some gamma rays will still give appreciable radiation through 12 in. of steel. The fourth type of ray, neutrons, are

TABLE I

THE NINE MOST USEFUL ISOTOPES

ISOTOPE	HALF LIFE	USEFUL RADIATION	ENERGY MEV	USED IN	TO MEASURE & CONTROL
Thallium 204	4.1 years	Beta only	0.8	Thin sheet gages	Fine paper, newsprint, tissue, plastic film.
Strontium 89-90	25 years	Beta only	2.3	Thin sheet gages, reflection gages, coating gages	Board, metal foil, thin sheet rubber, linoleum. Calendering operations, chiefly paper and rubber.
Cerium 144	290 days	Beta Gamma	3.0 0.085	Thin sheet gages	Intermediate grades of steel sheet.
Ruthenium 106	1 year	Beta Gamma	3.5 0.7 (average)	Thin sheet gages	Top range of beta gages — up to 0.070 in. steel. Glass and slag, wool fibre.
Iridium 192	75 days	Gamma	0.35	Corrosion gages	Plate, pipe and tank wall thickness. Also used for industrial radiography.
Caesium 134	2.3 years	Gamma	0.7	Some varieties of level gages	Liquid level in tanks.
Caesium 137	33 years	Beta Gamma	0.5 0.6	Some varieties of thickness gages	Finest grades of paper.
Cobalt 60	5.3 years	Gamma	1.2	1. Density gages 2. Heavy sheet gages	1. Any fluid material. 2. Up to 1 in. steel sheet, hot or cold. Heavy grades of rubber (tires).
Radium	1,600 years	Gamma	0.8 (average)	Some level and corrosion gages	Level in tanks and storage bins. Pipe wall thickness.

absorbed in a more selective fashion, which is strongly dependent upon the composition of the absorber and not just its mass.

But the fact that a material gives off gamma rays does not completely classify it. Gamma rays cover a broad energy range. The energy of radiation, normally measured in millions of electron-volts (mev), is a measure of the wave length of the radiation and consequently of its penetrating power. For example, a low energy beta ray of say 0.8 mev will be completely stopped by 15 thousandths of an inch of steel, while a beta ray with an energy of 2.3 mev requires 45 thousandths of an inch of steel to stop it. A low energy gamma ray, 0.3 mev, has its intensity reduced to 1/250th by passage through 4 in. of steel, whereas a higher energy gamma ray, 1.2 mev, is reduced only to 1/16th intensity by the same thickness of steel.

Every radioactive material emits a characteristic type of radiation, which never varies. Some radioactive materials give off only beta rays, some only alpha rays, some (the majority) give off beta and gamma rays combined. If a particular radioactive isotope is selected, it will always give off the same type of ray with the same energy. For example, if thallium, a heavy metal like lead, is placed in an atomic reactor, it will be converted into a radioactive material called thallium 204. This thallium isotope only gives off beta rays, and the beta rays always have an energy of 0.8 mev.

For a control application, the radioactive material should be selected according to the material it has to penetrate. To control the thickness of tissue or fine paper, choose an isotope that gives off a low energy beta ray—thallium 204, for example. For the control of heavier board, linoleum, or rubber sheet, an isotope giving off a more energetic beta ray should be used; for example, strontium 90, with a 2.3 mev beta ray. To control a steel strip mill producing up to 1-in.-thick steel, or to control the density of fluid in an 8-in. pipe, beta-emitting isotopes can no longer be used. These applications require a gamma ray emitter; for example, the isotope cobalt 60, which gives off 1.2 mev gamma rays.

Up to now, alpha rays and neutron radiation have not been used in industrial control equipment.

Alpha rays, because they are ionized, are good for eliminating static, and they may have some future application as delicate position indicators. Neutron rays, which are used to locate producing zones in oil wells, have been proposed for the control of composition in chemical plants and refineries.

While the type of ray remains constant, the amount of rays given out by an isotope slowly decreases. This decrease is expressed in terms of half-life, the time taken for the number of rays given out per second to decrease to 50 per cent of the original value. The half-life is another important consideration in picking an isotope for a control application. All the isotopes used commercially have half-lives of six months or more—from 290 days for cerium 144 up to 25 years for strontium 90.

Table 1 lists radioactive isotopes for industrial instrumentation, their characteristics and applications.

RADIOACTIVE INSTRUMENTATION

A source of radiation and a detecting element form the heart of any radioactive gage. There are several radiation detectors, but only three types are used in industrial gages and only one of these in control applications.

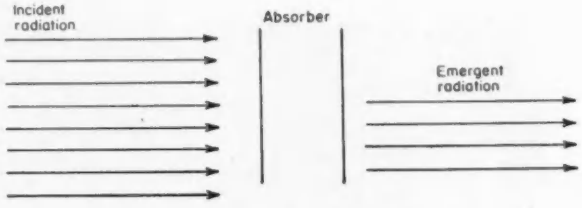
The highly sensitive scintillation detector—a crystal and photomultiplier combination—is used in some instruments for rapid scanning or for picking up a low radiation field (for example, some reflection-type gages).

The geiger tube detector is used in some simpler gages, such as radiation-level alarms for ensuring that tanks are not overfilled. Although it is the cheapest detector, it has neither the stability nor the long life required for an accurate analog instrument.

An ion chamber is always used as a detector in beta and gamma gages. Cylindrical, with a central collecting electrode, it, like the source, is varied in form according to its function, Figure 2. An ion chamber for a beta gage must have a thin foil window as the final closure, often 0.001 in. stainless steel foil. This window is not required for gamma ray gages since the gamma radiation can penetrate the chamber wall, generally with little loss in intensity. Thus, if necessary, a gamma gage chamber can be filled with gas under pressure. Since the generated signal is directly proportional to the mass of gas in the chamber, this increases the sensitivity of the gage.

In beta ray gages, small ion chambers are often used for spot readings. But for control applications, especially in the control of paper machines, some averaging is necessary to prevent the control from being based on purely local variations. An extended source and a long ion chamber is one way of achieving this. Figure 2 (A) shows a beta gage ion chamber that averages the radiation emerging from about a 14 in. width of the controlled material.

The first basic division of radiation gages is into beta and gamma instruments. The second division is into transmission and reflection instruments. A transmission gage, the more common type, has the source and detector on opposite sides of the material to be measured, whereas a reflection type has them on the same side, measuring the radiation scattered back from the material. In both types, the source and detector have to be mounted rigidly with respect to each other.



This simple illustration demonstrates the basic principle of all radiation instruments. The amount of emergent radiation varies with the mass of the absorber. FIG. 1

This problem is generally not too severe in transmission gages using gamma radiation. For example, in a density gage the source and detector are often mounted rigidly on the outside of the pipe carrying the fluid that is to be measured. In a steel rolling mill the gage can be mounted integrally as part of the rolling machine. In any case, the source and detector may be 18 or more inches apart, and a vibration of 1 or 2 thousandths of an inch is not very significant.

But in a beta gage, where the source and detector may only have a 1-in. gap between them, vibration is significant. A heavy yoke joins the source and detector of most beta gages. The throat of this yoke is occasionally as deep as 6 ft., Figure 3. By this means the gage head can be located at any desired spot across a wide sheet. In certain gages of this type the head is automatically driven back and forth across the sheet. This results in a scanning action.

The reflection-type gage, which relies on reflected radiation, is inherently a less sensitive instrument. However, it is valuable for measurements where the location allows access from only one side. For measurement of the wall thickness of closed tanks or pipes, for example, a reflection gamma gage is the only solution. For the measurement of rubber or paper on the roll during callendering a beta "backscattering" gage may be used. In these gages, a shield has to be used to prevent the detector from "seeing" the direct rays from the source. This presents no problem in beta equipment, but gamma reflection gages are more difficult to construct. In fact, the whole source assembly becomes bulkier in all forms

of gamma ray gages, since for personnel protection it is necessary to surround the source with a heavy shielding block of lead or other heavy metal.

The basic problem in all radiation instruments is one of stability. Several factors make for instability in these gages—statistical fluctuations in the radiation from the source, variations in detector power supply, source decay, amplifier instability, temperature and pressure effects, to mention the most significant. The history of beta gage development in particular has been one of steady elimination of these factors, until now accuracies of 0.1 per cent have been achieved under best conditions.

By incorporating a single design feature—balanced operation—several sources of instability can be removed. This means that the instrument contains a second source and chamber in addition to the measuring source and chamber. The two sets are connected so that the output signals are in opposition.

In beta gages an identical source is used, while in gamma gages the balancing source is often a beta source with approximately the same half-life. The balancing source has a controllable iris, so that it can be set to any desired value. Instead of the amplifier handling the full current coming from the measuring head, it receives only the very small currents caused by the deviation from standard; for example, a signal corresponding to the "off-weight" factor of a sheet of paper. This reduction in current brings the dc amplifier into a more stable operating range. At the same time, the balanced source also compensates for source decay. The measuring source and the balancing source are decaying at the same rate, and the difference current remains constant.

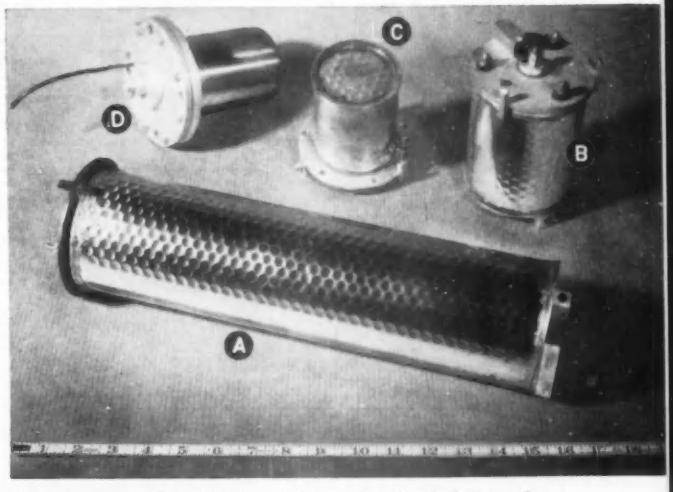
When beta instruments are gaging very fine paper, the air in the measuring head may weigh almost as much as the paper. This air will change in weight with the temperature of the surroundings and barometric pressure. But by making the air gap between the balancing source and head identical with that between the measuring source and head, this source of error is avoided. In gamma gages of the thick steel and density types these finer points are unimportant, but balanced operation still preserves its original function of stabilizing the amplifier.

Balanced operation is used in a tricky way in the measurement and control of coatings. Here the balancing source and detector are identical in design and function with the measuring source and detector. One head is mounted opposite the uncoated stock, the other opposite the coated stock. As before, the two heads are coupled in opposition. The resulting current gives a stable measure of coating thickness that can be adapted to coating control.

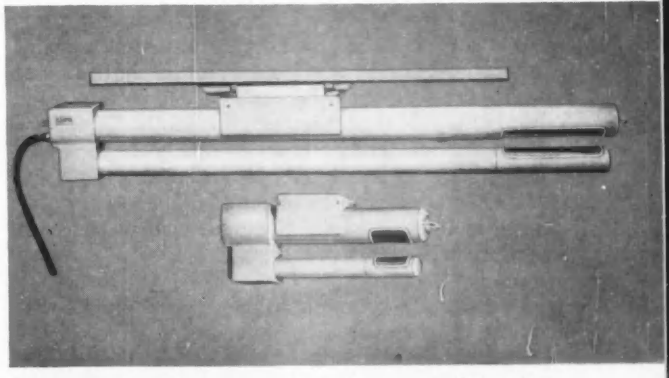
CONTROL CIRCUITRY

The most widely accepted instrument in this field is the beta-ray gage, which is used to measure the mass per unit area of paper, plastic, or rubber, or the thickness of light steel or brass strip. Figure 4 shows a block diagram of a typical circuit used in a beta gage system.

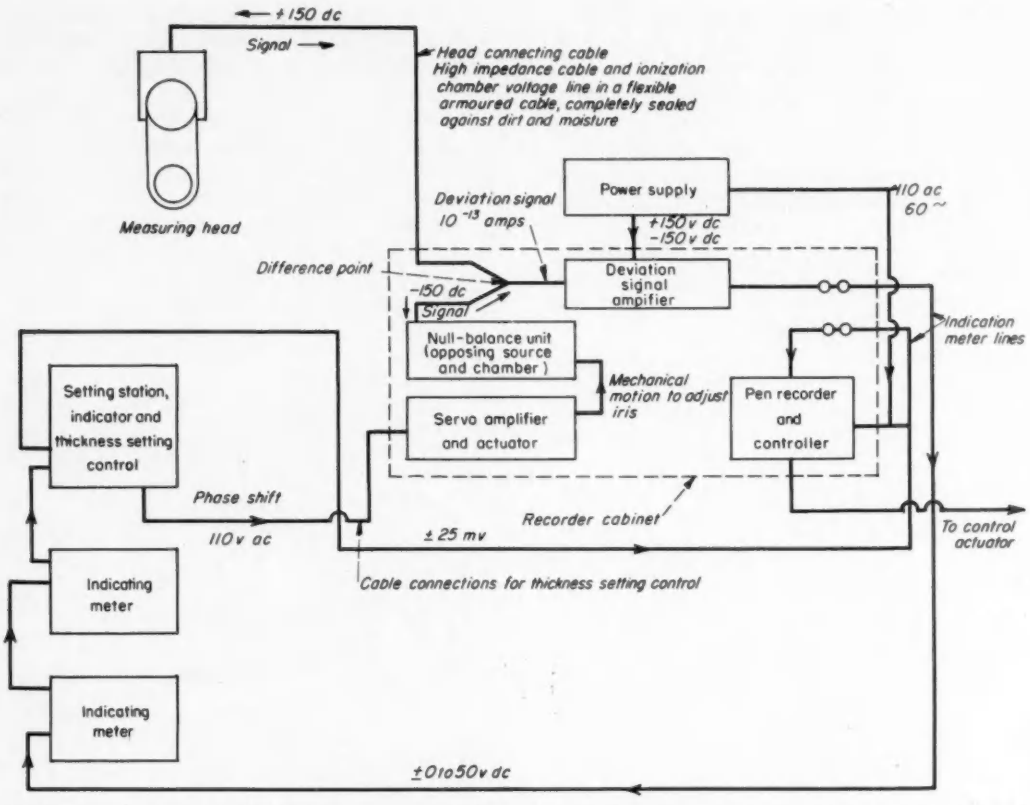
The output from the measuring head is bucked against the output signal from an adjustable balancing source and chamber. The set point for the measured quantity is adjusted by varying an iris-like opening in front of the balancing chamber through the setting station and the servo amplifier and actuator. The difference, or deviation signal, is amplified and used to drive the recorder, indicators,



Typical ion chamber detectors. Designs are simple but insulation requirements are critical. (A) is an extended beta gage detector while (B) shows a standard type of this device. (C) is an internal-balancing beta gage detector. (D) is a gamma gage chamber. This unit is pressurized to ten atmospheres of dry argon gas and in operation is encased in a heavy aluminum casing. FIG. 2



Contrast in size of beta gages. Note heavy yoke that maintains relative positions of source and detector. Unit with 6-ft throat measures thickness of fine paper. Smaller gage is used on a rubber calender. FIG. 3



Block diagram of circuit in typical beta gage instrument. Unit is equipped for indicating, recording, and controlling. FIG. 4

and control actuator. Standard types of compensating and stabilizing networks can obtain proper system response.

In paper-machine control where there are a number of uncontrollable variables, a variation of an ON-OFF control regulates the stock flow and maintains a good average basis weight sheet.

The ON period is varied depending on the amount the recorder pen has deviated from the control point during the previous OFF period. A correction made during the ON period restores the pen to the control point. No further correction is made until the effect of this change is detected by the measuring head. The OFF period can be preset so that as soon as the effect of the previous ON period change has been measured, a further correction can be made if necessary.

Occasionally, photomultiplier tubes replace the ionization chamber as a detector of radioactivity. Here the beta or gamma rays are converted to light pulses by a crystal, usually sodium iodide or anthracene. The output from the photomultiplier can be either converted to a dc signal or retained as pulses and further amplified. A photomultiplier tube is not often used where high accuracy and long term stability are important.

CONTROL APPLICATIONS

The following applications are typical of the field. In the first a beta gage controls the mass per unit area of a roofing paper, in the second it controls the thickness of copper strip, and in the last a gamma ray gage controls the density of a liquid-solid mixture flowing in a pipe.

Figure 5 shows a photograph of the beta gage equipment installed on a roofing paper machine and a block diagram of the system. The beta gage produces a signal inversely proportional to the mass per unit area of the paper. This signal is bucked against the output of a balancing chamber. The difference is amplified and used to open or shut the stock gate valve depending on the direction of the error. The measurement is made while the sheet still contains 65 per cent water. Measurement at the wet end of a paper machine means that changes can be detected much earlier, and avoids putting off-weight paper through the dryer section of the paper machine.

Figure 6 shows a copper strip mill with beta gage

control equipment. System is similar to those previously described, except that control function regulates the pressure on the rolls to maintain constant thickness. Notice the accuracy of the measurement and control at a speed of 2,000 ft per min.

When strip steel is being rolled, beta ray instruments are good for thicknesses up to 0.070 in. For thicker strip and hot strip, gamma radiation is used.

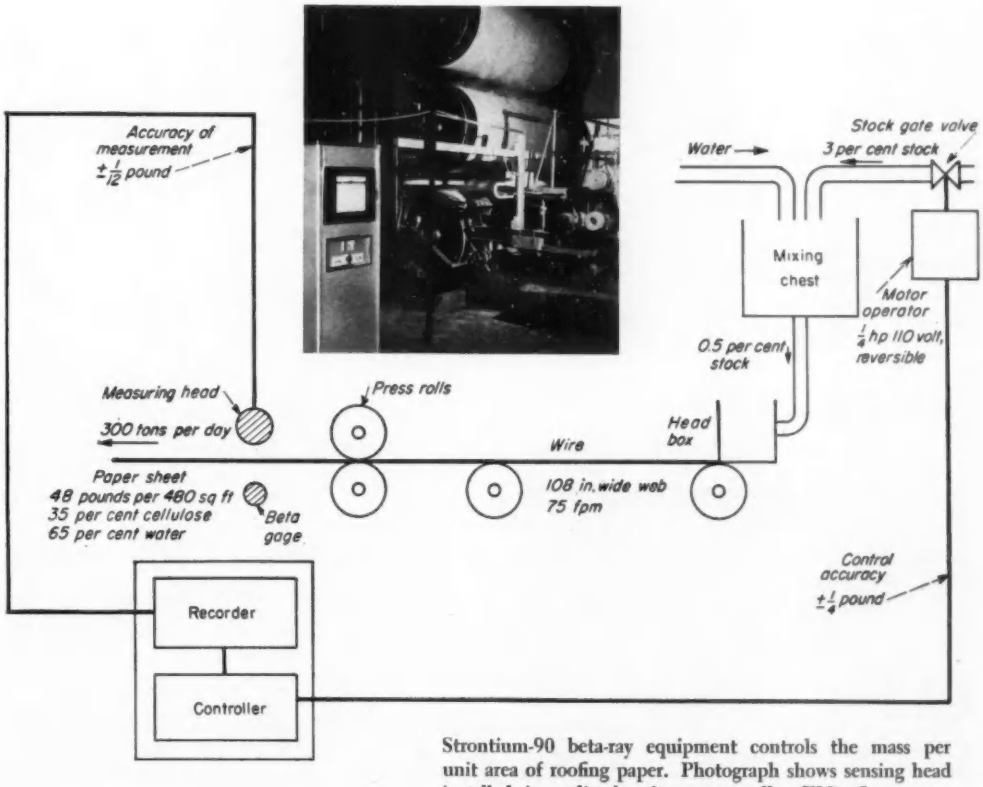
One of the most useful applications of radioactive instruments is the control of the density of liquids flowing in a pipe. Figure 7 shows a block diagram of an automatic control system for maintaining a constant percentage of solids in ore pulp. The gamma ray equipment in this application is shown in the photograph. Notice the heavy lead box surrounding the cobalt source.

The control signal either regulates a valve in the water line or a gate in the trough feeding solids from the ball mill. In either case, the control accuracy is within plus or minus 0.25 per cent of the solids.

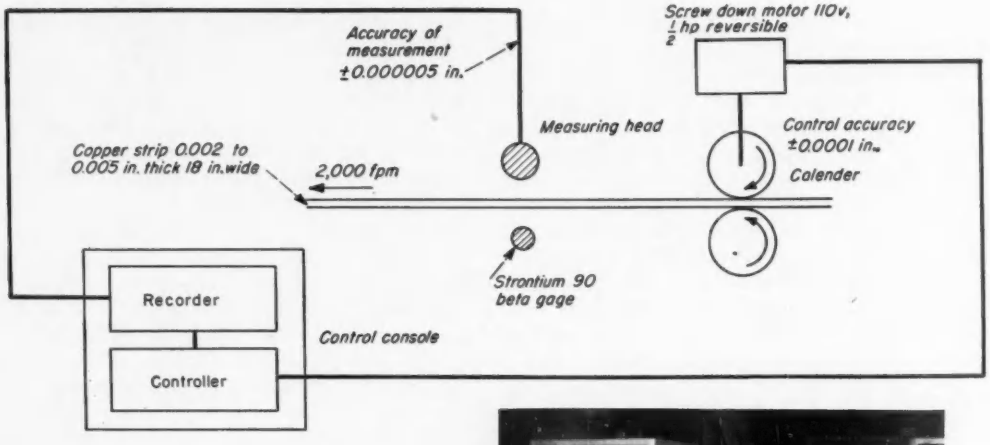
Density-type radioactive equipment can be used with any fluid. In the liquid range it has been used on anything from the lightest petroleum fractions to very heavy ore and pigment suspensions—specific gravities ranging from 0.6 to almost 3. The gamma gage will also measure the density of powdered solids, but its range does not include gases. A few of the materials and applications this equipment has been used on include: sulfuric acid dilution, sugar concentration, mineral suspensions in water, as a batching indicator in oil product pipelines, on asbestos slurries, density of cosmetic products, and the control of salt water in crude oil at the wellhead.

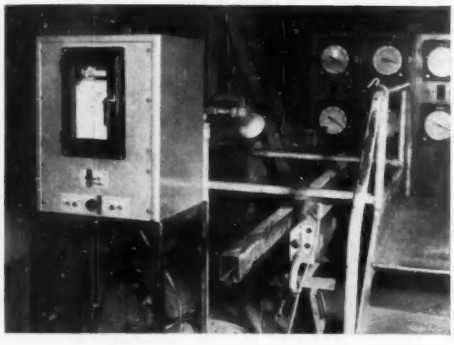
Since the gamma-ray gage is a noncontacting piece of equipment that mounts on the outside of a pipe or vessel, it is ideal for materials that could gum up or corrode immersed measuring equipment. The accuracy of the method depends to some extent on the path length available in the liquid for the rays to travel through. It also depends on the thickness of the metal pipe or vessel wall that the rays must traverse. Normal recommendations are 8 to 10 in. pipe for the heavier fluids, Figure 8, and up to a 24 in. pipe for the light gasoline fractions. The vessel walls should be as thin as possible for the greatest accuracy, but even 1.5 in. thick walls and brick-lined vessels can be penetrated.

Accuracies within 1/20 of one per cent have been obtained with this equipment, and a practical working figure for the field can be taken as 2 to 10 times this. In the application shown here, accuracy was reduced so that the range could be increased.

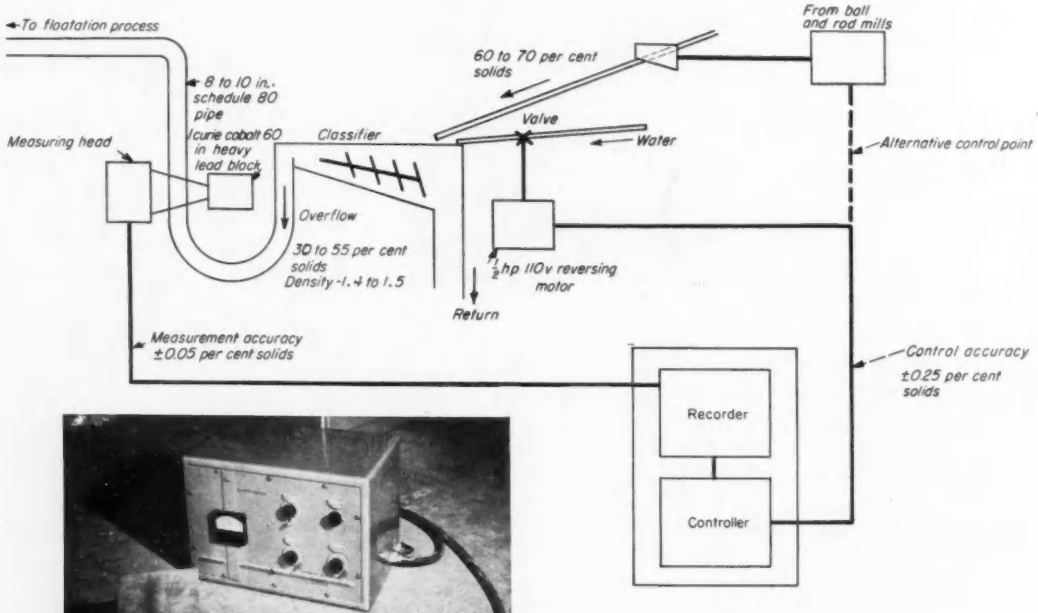


Strontium-90 beta-ray equipment controls the mass per unit area of roofing paper. Photograph shows sensing head installed immediately after press rolls. FIG. 5





Beta gage instrumentation on a copper strip mill. Cabinet in the foreground contains recording, indicating, and control equipment. Radiation instruments have increased the accuracy, speed, and efficiency of all types of strip mills. FIG. 6



Gamma-ray density control system maintains a constant percentage of solids in ore pulp. Photograph shows lead covered gamma ray source, detection chamber, and control cabinet. FIG. 7

Basic Math With AC Analogs

THE GIST: Certain basic mathematical operations can be simulated by analog devices. From these basic components are built solutions of the most complex military and industrial problems. This article describes how these fundamental operations are handled in ac electromechanical analog computers. Here are the mechanics of simulation plus some of the practical limitations.

GARETH M. DAVIDSON, American Bosch Arma Corp.

Basic computer functions may be classified as:

ARITHMETIC
- Addition and subtraction
- Multiplication and division

CALCULUS
- Differentiation
- Integration

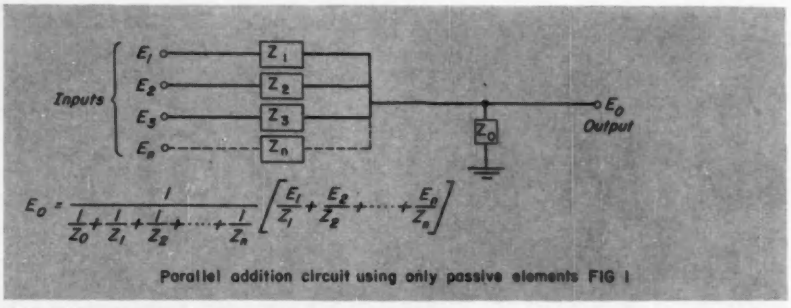
FUNCTION GENERATION
- Algebraic
- Trigonometric
- Others

ADDITION AND SUBTRACTION

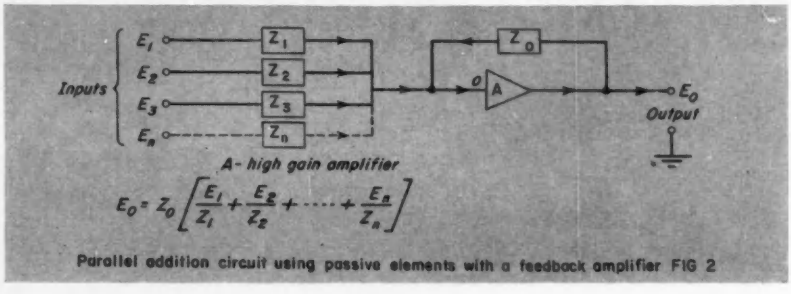
Addition and subtraction are fundamentally important in almost any computer. In ac electromechanical systems, the signals added are usually electrical voltages. There are two ways.

▶ **Parallel Addition**—The basic circuit for parallel addition is Figure 1 (next page). The only components are the passive impedance elements Z_1, Z_2, . . . Z_n. In practice these are usually precision resistors, but they can be capacitances or inductances.

The principle advantages of parallel addition are simplicity and the fact that the input signals E_1, E_2, . . . E_n may all be referred to a common return point or ground. Without this feature it would be necessary for all of the input sources to be electrically



Parallel addition circuit using only passive elements FIG 1



Parallel addition circuit using passive elements with a feedback amplifier FIG 2

isolated from each other. The circuit in Figure 1 is not highly accurate. Among its drawbacks are:

a. Loading at the output changes the effective value of Z_o and produces a direct scaling error.

b. A scaling error is introduced if the number of input sources is changed.

c. Each of the isolating impedances $Z_1, Z_2, \ldots Z_n$ acts as a load on all of the inputs simultaneously. This causes interaction among the input voltages $E_1, E_2, \ldots E_n$.

d. For accuracy the impedances $Z_1, Z_2, \ldots Z_n$ should be high compared to the respective input impedances. This often raises the over-all impedance level of the circuit to a level where pick-up from extraneous sources may become a problem.

e. To minimize the effects of interaction among the various inputs, the output voltage should be as close to ground potential as possible. This results in a high attenuation of signal from input to output.

f. The accuracy of the parallel addition circuit depends directly upon the stability of the impedances $Z_1, Z_2, \ldots Z_n$. Hence components must be precise.

Most of these difficulties can be overcome by a feedback amplifier added to the parallel-addition circuit as in Figure 2. This circuit has the same number of impedance elements, but negative feedback tends to keep point "O" very close to ground potential. This leads to some important advantages:

1. The output impedance of the feedback amplifier is low. An appreciable load can be drawn from the output without seriously reducing accuracy.
2. The scaling constant is practically independent of the number of input sources.
3. Interaction among the inputs is practically negligible, because point "O" is automatically maintained close to ground.
4. Suitable choice of impedance element values brings about overall voltage amplification.

The accuracy of the addition circuit in Figure 2 still depends directly on the stability of the impedance elements $Z_1, Z_2, \ldots Z_n$. Precision components must be used. There is also a finite current drain from each of the input sources $E_1, E_2, \ldots E_n$ depending upon the magnitude of the respective isolation impedances. These two disadvantages can be removed by series addition.

► **Series Addition**—The basic circuit is shown in Figure 3. All but one of the voltages to be added must be isolated from ground. For this reason transformers are used to isolate the input sources from the addition circuit. The two advantages of this circuit over the one shown in Figure 2 are:

1. Long-term accuracy depends only upon the stability of the transformation ratio of the isolation transformers and not upon any external precision impedances.
2. The current drain, determined directly by the load, can be made negligibly low.

This circuit has limitations also, such as:

a. Losses in the isolation transformers contribute errors to the system. In most practical transformers these losses are also non-linear with respect to the signal level.

b. Appreciable loading may exist from stray capacities to ground at various parts of the circuit. This serves to limit the number of voltages that can be added using the series circuit configuration.

c. Serious pickup problems arise, except when the input source impedances are rather low. Step-down isolation transformers help, but attenuate signals.

The choice between parallel and series addition usually depends on which factors are important in any specific problem. In some cases either method may work equally well.

▶**Addition of Mechanical Inputs**—Two or more mechanical displacements or rotations can be added either by converting the mechanical quantities to electrical signals or by adding them directly, as with a gear differential. Strictly mechanical adders will not be discussed here.

The synchro-differential generator is an adder that may be considered somewhat of a hybrid component, since one input is mechanical while the other is electrical. This is illustrated in Figure 4.

The output is electrical, generally in the form of a three-wire synchro signal, as is the electrical part of the input.

MULTIPLICATION

Consider first the problem of multiplying a mechanical variable (usually a shaft rotation) by an electrical voltage.

▶**The linear resistance potentiometer** is one of the devices most commonly employed for multiplying. The principle is in Figure 5 (next page). The output voltage E_2 is proportional to the product of the input voltage E_1 and the shaft input angle Θ.

The most accurate potentiometers in actual use are of the multiturn wire-wound type. In high quality units the linearity error can be as low as 0.01 per cent of maximum output. Resolution in wire-wound components is always finite because of the "stepping" effect between turns. Essentially infinite resolution can be had by using either the continuous spiral potentiometer or the continuous film type. This is generally at the expense of increased linearity error, and this must be considered.

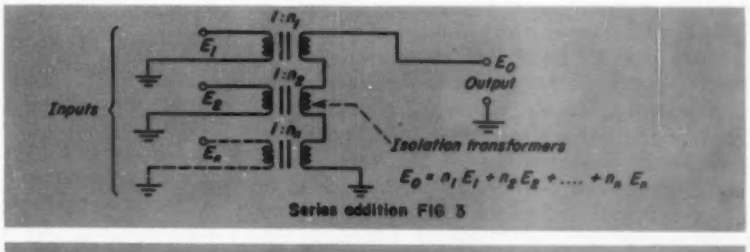
One of the limitations of the potentiometer as a multiplier is the non-linearity caused by loading. The source impedance of the potentiometer is variable, depending on both the resistance between ends and the angle of rotation. A precision isolation feedback-amplifier is often connected between the output and the load to preserve the inherent accuracy of the potentiometer. [See "Compensating Pot Loading Errors," CONTROL ENGINEERING, February, 1955]

▶**The induction potentiometer** is another device often used as an electromechanical multiplier. This is generally a rotating component consisting of an excitation or field winding and a rotating pickup coil. It is specially constructed to make the voltage induced in the pick-up coil a linear function of the angle of rotation over a limited range (see Figure 6).

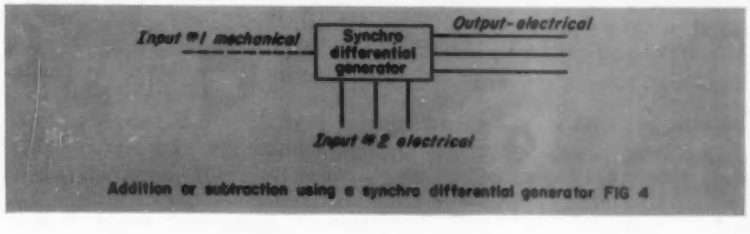
One of the advantages of the induction potentiometer is that its output voltage is a smooth continuous function of the angle of rotation. Also, with no moving brush contact, the wear problem is considerably minimized. Another advantage is the isolation of the input from the output.

It is usually necessary to compensate for the inherent losses and phase shift through the unit to achieve optimum performance. This normally requires a special booster amplifier. Some designs have linearity errors as low as 0.1 per cent.

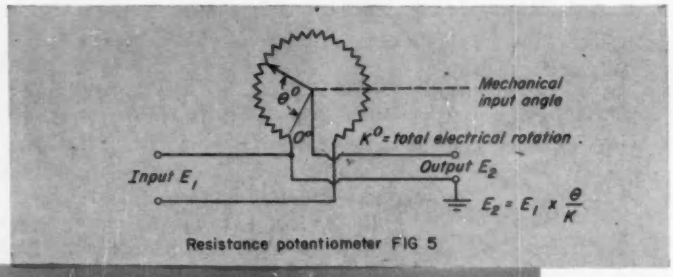
▶**The toroidal potentiometer,** or variable auto-transformer, is one of the most promising electromechanical multipliers. A commercial form is the "Variac." It is similar to the resistance potentiometer in Figure 5, with the exception that the turns of wire are wound on a high-permeability magnetic core rather than on a non-magnetic core. The inductive effect of the core raises the input impedance by a large factor, while the output impedance is not changed appreciably. The output voltage derives



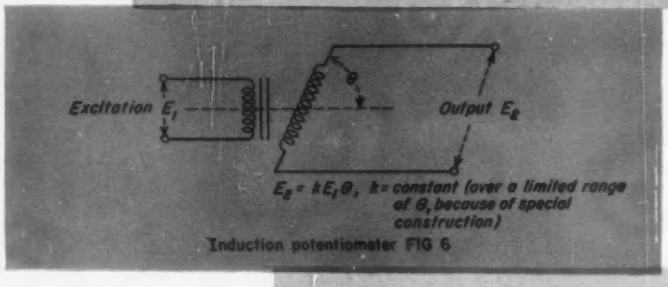
Series addition FIG 3



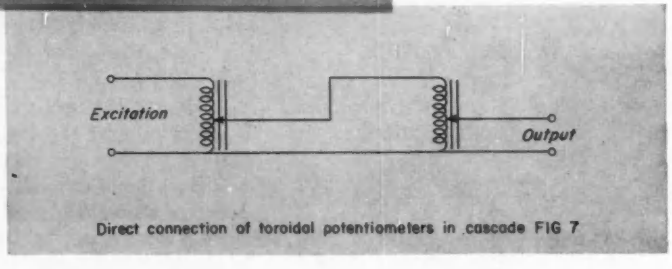
Addition or subtraction using a synchro differential generator FIG 4



Resistance potentiometer FIG 5



Induction potentiometer FIG 6



Direct connection of toroidal potentiometers in cascade FIG 7

primarily from an induced emf, making the accuracy substantially independent of the uniformity of wire size. The type of brush contact is somewhat critical, since a short circuit between turns draws a large amount of power owing to transformer action. Thus the shorting resistance of the brush must be controlled. In practice this is not serious.

One important feature of the variable auto-transformer is its high ratio of input to output impedance. Practically speaking, this means that toroidal potentiometers often can be connected in cascade without an isolation amplifiers in between, as in Figure 7.

Another advantage is that problems of phase shift and errors due to losses are minimized by the inherent properties of an auto-transformer. The input impedance, though relatively high, varies as a function of the voltage excitation level because of the non-linear characteristics of the core. Wire "stepping" from one turn to the next tends to be smoothed out by the resistance of the brush contact. Over-all linearity errors of 0.1 per cent or better can be had in toroidal potentiometers.

Multiplying Two Voltages

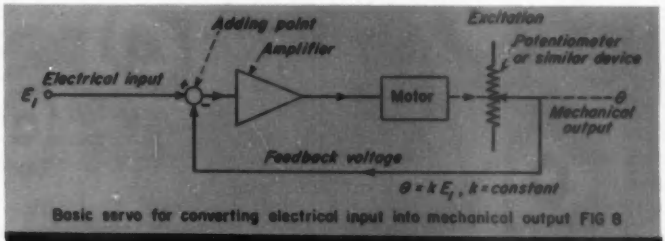
The next problem is that of multiplying two ac carrier voltages. Much effort has been expended towards accomplishing this by purely electrical means. This includes such devices as special vacuum tube circuits, thermal elements, non-linear resistors, strain-gage transducers, magnetic circuits, and diode squaring circuits. Because these systems are so numerous, no attempt will be made to discuss them here.

► **The Servo Multiplier** is still widely considered the most accurate and most reliable, despite the fact that many different types of analog multipliers have been devised. The principle of operation is first to convert one of the voltages to a proportional mechanical displacement or rotation by a servo system. This mechanical quantity drives a standard electromechanical multiplier, such as a potentiometer.

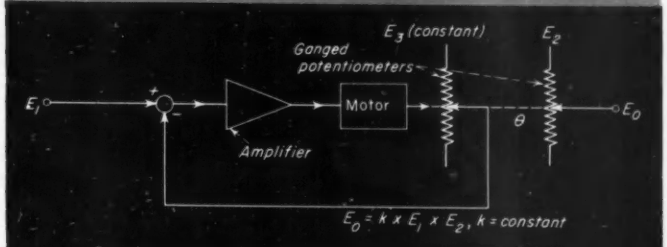
The elements of the servo system for converting a voltage into a shaft rotation are pictured in Figure 8.

Because of the action of the closed loop, the motor serves to position the moving arm of the potentiometer so that the feedback voltage is always equal to the input voltage, E_1, as shown. Because of the linear properties of the potentiometer, the output angle Θ is therefore also proportional to the input voltage. In practical systems this relationship can be maintained accurately. A diagram of the complete servo multiplier is shown in Figure 9.

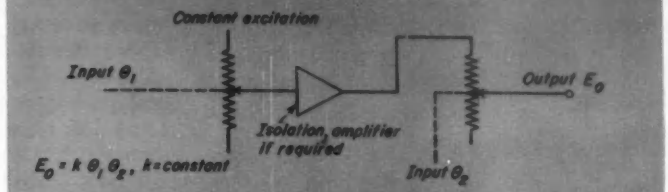
To perform the final multiplication, two potentiometers must be mechanically ganged so that their contact arms move together. The first servos the



Basic servo for converting electrical input into mechanical output FIG 8



Complete system for multiplication of two voltages FIG 9



Multiplication of two mechanical inputs FIG 10

position of the contact arm, while the second performs the multiplication.

Accuracy of the servo multiplier depends mainly on the quality of the ganged potentiometers. Therefore, the system shown is inherently capable of accurate, reliable performance. Errors of less than 0.1 per cent of maximum output are easily obtainable.

The chief drawbacks of the servo multiplier are its bulkiness due to moving parts, and its high cost, because of the large number of components involved. Also, the time response characteristic of the servo limits response at the output. Despite these limitations, it is widely used in analog computer systems.

When both variables are mechanical inputs, they can be multiplied in several ways. One method converts one of the inputs to an electrical signal by using a potentiometer. This signal and the other mechanical input then feed to a second potentiometer where the multiplication is performed. Such a system is illustrated in Figure 10.

A second method feeds the two inputs directly to a mechanical multiplier. This may take the form of linkages or non-circular gears, and will not be discussed here.

DIVISION

Division is more difficult to handle in analog computers, since the output tends to increase beyond bound when the denominator becomes small compared to the numerator. Hence, it is necessary to limit the inputs to prevent the output from becoming saturated. For this reason division is often avoided in actual systems.

In general, most multipliers are suitable also for division. For example, consider Figure 9. This circuit can be used for dividing by making the excitation voltage E_3 one of the input variables and keeping the input voltage E_2 constant. Then, since the output voltage of the first potentiometer is always kept equal to the input E_1, it follows that:

$$E_3 \times k_1\theta = E_1$$

$$\text{or } \theta = \frac{1}{k_1}\frac{E_1}{E_3}$$

$$\text{Since } E_o = k_2 \times \theta$$

$$E_o = \frac{k_2}{k_1}\frac{E_1}{E_3} = k\frac{E_1}{E_3},\ k = \text{constant}$$

Hence the voltage E_1 is divided by the voltage E_3. If the voltage E_2 is also allowed to vary, then multiplication and division may both be performed simultaneously.

As the excitation voltage E_3 approaches zero and E_1 remains constant, the angle θ becomes larger and larger until the maximum travel of the potentiometer is reached. A second difficulty is that the servo performance deteriorates as E_3 decreases, because of

the resulting reduction in loop sensitivity. These limitations make it necessary to restrict the range of the input variables.

Another way to divide is to convert the divisor into its reciprocal and then multiply. This is shown in block form in Figure 11.

The reciprocal transducer is generally some nonlinear device such as a specially constructed potentiometer or a cam. High accuracy is hard to get.

DIFFERENTIATION

In ac electromechanical systems, differentiation is usually performed by the induction generator. This is an ac tachometer with carrier-frequency electrical output directly proportional to the instantaneous velocity of the input shaft. A carrier-frequency voltage excitation of constant magnitude must be supplied, as in Figure 12.

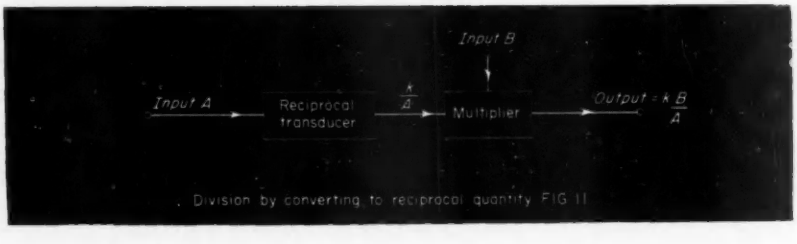
The derivative operation indicated in Figure 12 is specifically with respect to the time variable. While differentiation with respect to an independent variable can be performed with some difficulty, this kind of function is rarely required in analog computer operations.

► **The induction generator** is generally of the drag-cup type. The pickup winding is wound in space quadrature with the excitation winding on a magnetic structure. And the voltage induced in the pickup winding is varied by the speed of a conductive cup rotating in the magnetic field. This is similar to the construction of an ac induction motor.

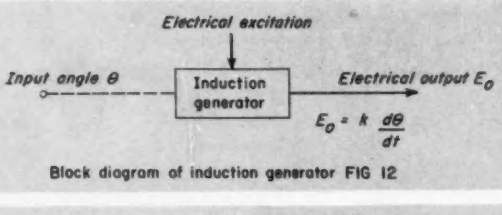
Several sources of error exist in induction generator design. There are problems of phase shift, temperature, axis misalignment, and high output impedance. The noise output at zero speed limits the maximum sensitivity. In a well-constructed unit, linearity errors as low as 0.1 per cent are obtainable.

► **Other methods** of generating the time derivative can be used where lower accuracy can be tolerated. For very crude applications tuned carrier-frequency networks may be used. These suffer from the drawback that they are extremely sensitive to carrier-frequency variations. It is also possible to utilize the inherent time lag of certain thermal resistance elements to produce a derivative output. Another common method is to convert the ac input signal into a dc signal and apply it to a dc derivative network, which may include an operational amplifier. The output of the dc network is then converted back to its ac-carrier form to provide the desired output. This system is illustrated in Figure 13.

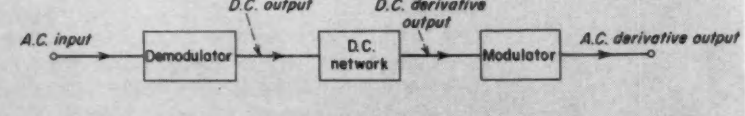
The chief sources of error are in the demodulator and modulator conversion units. A minimum transformation error of at least 1 per cent in both the demodulator and modulator may be expected. In addition, harmonic noise filtering may be required; this will contribute time delay to cause a dynamic error in the differentiation process. Thus, this type of device should be considered only for medium-accuracy applications.



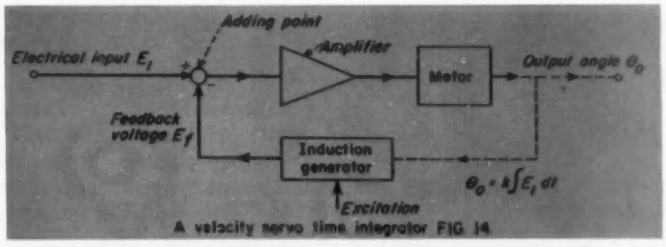
Division by converting to reciprocal quantity FIG 11



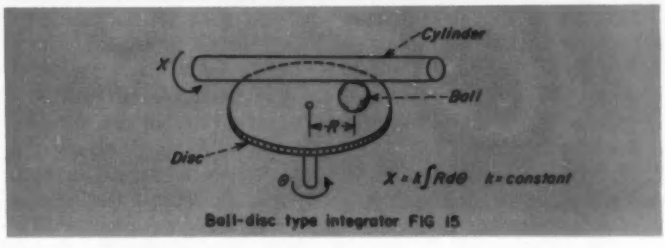
Block diagram of induction generator FIG 12



Differentiator using A. C. to D. C. conversion FIG 13



A velocity servo time integrator FIG 14



Ball-disc type integrator FIG 15

INTEGRATION

The most common integrators in ac analog computers are the velocity servo and the ball-disc integrator.

▶ **Velocity Servo**—Integration with respect to time is usually done by a velocity servo with an induction generator in the feedback path. The basic system is shown in Figure 14.

The input is an electrical signal voltage E_i, and the output is the mechanical angle of rotation θ_o, of the induction generator. The closed-loop servo keeps the feedback voltage E_f equal to the input E_i.

Owing to the differentiating action of the induction generator, however,

$$E_f = k_1 \frac{d\theta_o}{dt}$$

$$E_i = E_f = k_1 \frac{d\theta_o}{dt} \quad .$$

$$\theta_o = \frac{1}{k_1} \int E_i\,dt = k \int E_i\,dt, \qquad \text{k = constant}$$

Hence, the output angle is proportional to the time integral of the input signal. Initial conditions for a particular problem can be inserted mechanically at the output through a differential, or by a voltage in the electrical part of the integrator.

The accuracy of the system depends to a large extent on the precision of the induction generator. Any zero-speed noise output from the generator or other sources will be sensed as an extraneous input and integrated by the servo. This results in a constant drift rate at the output. Because of this integrating effect, even a small noise signal at the input will accumulate to a large error.

To minimize the error from drift due to noise, it may be necessary to use a short solution time for a given problem. The scaling for a particular problem should be such that the maximum required speed is close to the rated generator speed, thereby giving a maximum signal-to-noise ratio.

Dynamic performance is another limiting factor in the accuracy of the velocity-servo integrator. This is a consequence of the system inertia and its inability to respond instantly to changes in the input signal. Referring to Figure 14, if the input changes rapidly enough, the servo cannot keep the feedback voltage E_f equal to the signal voltage E_i, and the integral relationship at the output is disturbed. In practice the magnitude of the dynamic error must be controlled by servo design.

▶ **Ball-Disc Integrator**—This is a purely mechanical device for integrating one variable with respect to another independent variable. It can have relatively high accuracy. A simplified representation is given in Figure 15. There are essentially three variables. These are the angle of rotation of the disc θ, the angle of rotation of the cylinder X, and the distance R from the center of the disc of the contact point between the ball and disc. The ratio of the speed of rotation of the cylinder to that of the disc is directly proportional to the value of the radius R.

The integral relation indicated in Figure 15 may be derived as follows: Assume that for given positions of the ball and disc, the disc is given a small rotation of $d\theta$. The corresponding angular rotation of the cylinder, dx, is given by:

$$dx = kR\,d\theta$$

Since this holds for all instantaneous values of R and θ, both sides of the equation may be integrated to give:

$$x = k\int R\,d\theta$$

It is assumed that there is no slipping between ball and disc or between ball and cylinder.

The accuracy of this integrator depends on production tolerances. Good machining can hold the maximum error to very small values. The output shaft of the cylinder should not be loaded appreciably, since this tends to cause slippings. For heavy loads a servo repeater is recommended.

▶**Other Integrators**—Several other integrators are available, mostly with lower accuracy:

a. AC-carrier networks—These include the series-tuned or parallel-tuned circuits, the parallel "T" network, and certain bridge circuits. They are all extremely sensitive to variations in the carrier frequency and give rather low accuracy.

b. DC-networks—The ac-signal can be demodulated to a dc signal and passed through a dc network, which may contain an operational amplifier. The output then goes through a modulator and back to its carrier form. Errors of a few percent may arise in the demodulator and modulator circuits.

c. Thermal integrators—The time lag of certain thermal resistance elements can be used, together with a feedback amplifier. Accuracy of this method needs investigation.

d. Torque methods—A torque proportional to an electrical signal is applied to a shaft having a high degree of viscous damping. The output angle is then very nearly proportional to the integral of the input signal. Also, the rate of precession of a gyro about an axis perpendicular to both its spin axis and the axis of applied torque is proportional to the applied torque. Thus, the angle of precession corresponds directly with the integral of the input signal.

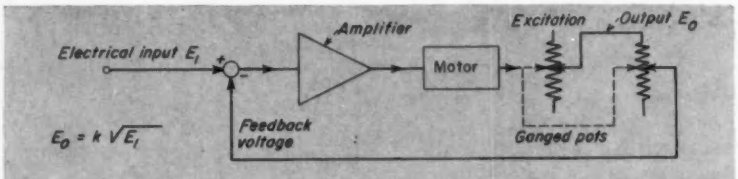
e. Motor integrators—If the speed of a servo induction motor is assumed proportional to the voltage on the control field, then the output shaft angle is directly related to the integral of the control voltage. Appreciable errors are caused by the inertia of the motor and the nonlinearity of the motor characteristics. A demodulator and a specially designed dc motor also can be used in the same manner with reasonable accuracy.

FUNCTION GENERATION

In ac electromechanical systems, the problem of causing an output to vary as a given function of one or more input variables occurs frequently. This field is broad, and no attempt at complete coverage will be made.

▶**Algebraic Functions**—The servo multiplier is one of the most direct and most accurate methods of generating algebraic functions. It is possible to instrument the general function $y=x^n$, where n is any proper fraction. For example, Figure 9 shows a squaring device if the inputs E_1 and E_2 are equal. Several such units cascaded can raise the input to any integral power. If the input is mechanical, it is only necessary to gang the proper number of potentiometers and cascade them electrically.

To get the root of a number, inverse feedback must be used. As an illustration, a system for taking the square root is shown in Figure 16. This is a servo system in which the motor drives two cascaded potentiometers connected as a squaring device so that the feedback voltage is kept equal to the input voltage E_1. Since the feedback voltage is equal to $k_1E_o^2$ where k_1 is a constant, it follows that:



A system for generating the square root of a voltage FIG 16

$$k_1E_o^2 = E_1$$

or

$$E_o = k\sqrt{E_1}, \qquad k = \text{constant}$$

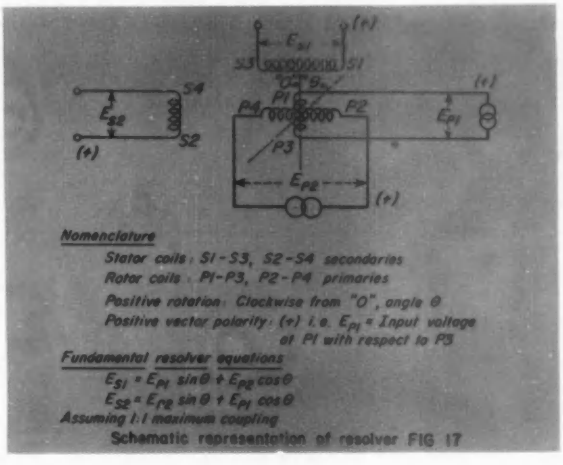
Similarly, it is possible to take any other root of an input quantity or to raise the input to any fractional power. As stated before, this method is relatively precise.

Other methods of generating algebraic functions are available and are discussed later in this article.

▶**Trigonometric functions**—Particular attention has been focused on the development of the ac electrical resolver for generating the sine and cosine functions.

A resolver is a precision rotary signal transformer capable of unlimited rotation and wound in a very special way. In its most general form it has two primary coils wound in space quadrature with respect to each other and two secondary coils, also wound in space quadrature. The two primaries move together and can be rotated relative to the secondary windings. The nature of the distribution of the windings is such that when either, or both, of the primary windings is excited from an ac source, both voltages induced in the two secondary coils vary sinusoidally as a function of the mechanical angle of rotation.

A schematic representation of a resolver is shown



Schematic representation of resolver FIG 17

in Figure 17. While the diagram shows the primary as the rotating member, the secondary may also be the rotor, with the primary as the stator.

The fundamental resolver equations are of exactly the same form as the equations of transformation used in rotating a set of rectangular coordinate axes through an angle θ. Resolvers are often used for this purpose. Conversion from polar coordinates to rectangular coordinates (resolution) also is possible. Thus, assume the primary voltage E_{p1} equals zero. If E_{p2} is considered analogous to the magnitude of the radius vector, and the angle θ represents the polar angle, then the secondary voltage E_{s1} is equal in magnitude and sign to the corresponding rectangular "x" coordinate while the secondary voltage E_{s2} is equal to the rectangular "y" coordinate.

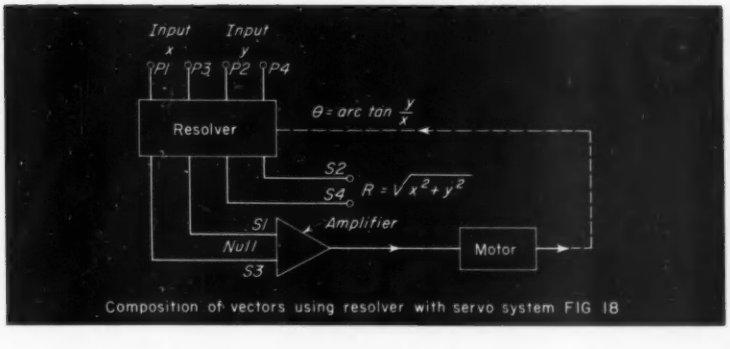
To convert from rectangular to polar coordinates (composition) a servo must be used as illustrated in Figure 18.

The motor drives the rotor of the resolver until the position of the secondary coil S1—S3 is such that there is zero net induced voltage between its terminals. At this point the voltage induced in the other secondary S2—S4 has its maximum value and is equal to the radius vector. The mechanical angle of rotation θ at this point, is equal to the polar angle. This operation is possible because the resolver performs vector addition internally.

There are numerous other applications of the resolver in the computing field. By suitable feedback arrangements it is possible to generate any of the other trigonometric functions or their inversions. If the two primary windings are excited by voltages of equal magnitude but in time quadrature, the time phase of the secondary voltages will correspond directly to the mechanical phase of the angle of rotation. The versatility of the resolver has enabled the designer to simplify the solution of many problems that otherwise would have required more cumbersome and indirect techniques.

Practically, some precautions are necessary for maximum resolver performance. Since it is an electromagnetic component with a magnetic core, the primary excitation must not be so big as to cause magnetic saturation. The scaling should be such that the minimum excitation will not become too low, or trouble may arise from pickup and low permeability of the core. Electrical loading on the secondary side must be kept to a minimum since the additional losses will cause errors.

In addition, the resolver, like any other transformer, has coil resistance, leakage reactance, core



Composition of vectors using resolver with servo system FIG 18

nonlinearities, and core losses. These cause phase shift and reduce transformation ratio. Changes in signal level and variations in ambient temperature may cause appreciable errors. To reduce these errors, each of the primary windings is often excited from a high-gain feedback amplifier with a special compensation net work. This is particularly important when resolvers are to be cascaded in computing chains. Such an amplifier is commonly termed a "booster" amplifier. Proper design and suitable external circuitry can limit resolver errors to only 0.1 per cent.

▶**Other function generators**—Many special devices are available to generate many different functions. Some of these are mentioned briefly below. This list is by no means complete.

a. Scotch yoke—This is a mechanical resolver used for generating the sine and cosine functions. It is a crank and slide arrangement. Reasonable accuracy can be obtained, generally at the expense of increased size and cost.

b. Specially loaded linear potentiometers—By connecting loading resistors of the proper value at suitable points on a linear resistance potentiometer, a large variety of important functions can be produced over a limited region, Figure 19. Accuracy depends on the range of variation of the input.

c. Potentiometers with non-linear windings—It is possible to vary either the spacing between wires or the wire size to obtain a desired distribution of resistance. Another way is to wind on a suitably shaped card. Reasonable accuracy can be obtained only by going to relatively large physical dimensions.

d. Mechanical cams—Many functions can be generated by driving an electromechanical transducer from a nonlinear mechanical cam. Certain restrictions must be placed on the derivative of a function obtained by this method. Wear due to rubbing is a problem.

e. Approximation by a series of straight lines—Sufficient accuracy may often be obtained by approximating the desired function with a series of straight lines. One straightforward way of doing this is to shunt various sections of a linear potentiometer with fixed resistors as in Figure 20. Other methods also produce a series of straight lines. For example, a switching arrangement can provide discrete steps while a potentiometer is used for interpolation. Accuracy improves as the interval between steps is decreased.

f. Non-circular gears—Several useful functions can be generated by mating eccentric gears. This mechanical technique appears to be quite reliable and is potentially accurate.

g. Linkages—Linkages have been used extensively in mechanical computers. They are simple, flexible and relatively small. Another useful feature is that linkages can easily be connected to perform several operations simultaneously. Because of inherent geometric errors, linkage-function generators are often restricted to a rather limited range of variation of the input variable.

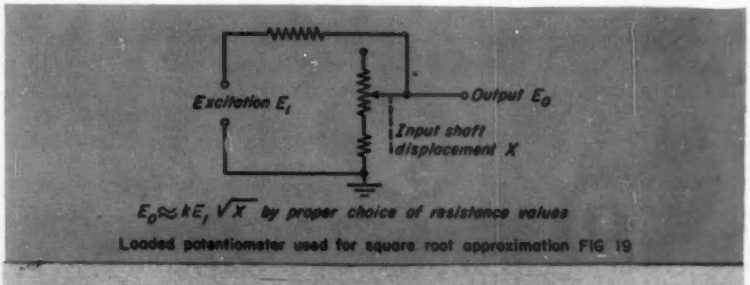
The author wishes to acknowledge the helpful suggestions contributed by Mr. J. Y. Kaplan and Dr. R. O. Bock of the Arma Division.

BIBLIOGRAPHY

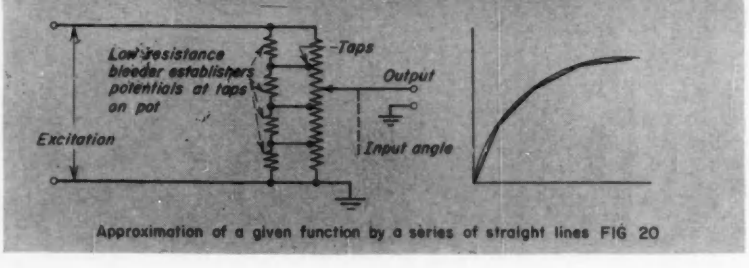
"*ELECTRONIC INSTRUMENTS*", edited by Greenwood, Holdam, and Macrea, M.I.T. Radiation Laboratories Series, Vol. 21, McGraw-Hill Book Company, Inc., 1948

"*COMPONENTS HANDBOOK*", edited by Blackburn, M.I.T. Radiation Laboratory Series, Vol. 17, McGraw-Hill Book Company, Inc., 1948

"*ROTATING COMPONENTS FOR AUTOMATIC CONTROL*", by S. Davis, "Product Engineering", November, 1953



Loaded potentiometer used for square root approximation FIG 19



Approximation of a given function by a series of straight lines FIG 20

PERIODICALS AND BIBLIOGRAPHIES FOR YOUR



Control Engineering Library

Here are the technical journals, the abstracting sources, and the bibliographies encompassing most of the important writings on control engineering

THOMAS J. HIGGINS, University of Wisconsin

TECHNICAL JOURNALS

Over the past decade the author has compiled a 3,612-item card index, alphabetized by authors, which lists most of the important technical papers (in English, French, German, Italian, and Russian) that have been published on automatic control. Sorting of these cards showed that the 3,612 papers appeared in 384 different journals. A count revealed that approximately 75 per cent of the total number were published in the 40-odd journals listed below.

American Institute of Electrical Engineers: Transactions (Parts I, II, III)
33 W. 39th St., New York 18, N. Y.

American Society of Mechanical Engineers: Transactions
29 W. 39th St., New York 18, N. Y.

Annales des Télécommunications
Centre National d'Etudes des Télécommunications, 24 Rue Bertrand, Paris (VII^e), France.

Archiv für Elektrotechnik
Springer—Verlag, Reichpietschufer 20, Berlin, W. 35, Germany.

Archiv der elektrischen Ubertragung
S. Hirzel Verlag, Birkenwaldstrasse 185, Stuttgart, Germany.

Association for Computing Machinery: Journal
2 E. 63rd St., New York 21, N. Y.

Automatic Control
Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.

Automatic Control (Japanese publication, in Japanese, but with abstracts of articles in English)
Society of Automatic Control, Institute of Industrial Science, University of Tokyo, Yagoicho, Chiba, Japan.

Avtomatika i Telemekhanika
Four Continent Book Corp., 38 W. 58th St., New

York 19, N. Y. (importers from the U.S.S.R., provide subscription service).

Automation
Penton Publishing Company, Penton Building, Cleveland 13, Ohio.

*Chemical Engineering
McGraw-Hill Publishing Company, 330 W. 42nd St., New York 36, N. Y.

*Computers and Automation
Edmund C. Berkeley and Associates, 36 W. 11th St., New York, N. Y.

Control Engineering
McGraw-Hill Publishing Company, 330 W. 42nd St., New York 36, N. Y.

Electrical Engineering
American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

Electrical Manufacturing
The Gage Publishing Co., 1250 Sixth Ave., New York, N. Y.

Electronic Engineering
28 Essex St., London W. C. 2, England.

Electronics
McGraw-Hill Publishing Company, 330 W. 42nd St., New York 36, N. Y.

*†Elliott Journal
Elliott Bros. (London), Century Works, Lewisham, London, S. E. 13, England.

Industrial and Engineering Chemistry
American Chemical Society, 1155 Sixteenth St., N. W., Washington, D. C.

Institute of Radio Engineers
Proceedings
Transactions (of pertinent professional groups)
1 East 79th St., New York 21, N. Y.

Institution of Electrical Engineers: Proceedings (Parts I, II, III, IV; as of January, 1955, three parts only). Savoy Place, London, W. C. 2, England.

*†Instrumentation
Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Wayne and Windrim Aves., Philadelphia 44, Pa.

*Instrument Engineer
George Kent Ltd., Luton, Bedfordshire, England.

*Instrument Practice
United Trade Press, Ltd., 9 Gough Square, Fleet St., London, E. C. 4, England.

Instruments and Automation (formerly Instruments)
845 Ridge Ave., Pittsburgh 12, Pa.

*Instruments in Industry
Herbert Publishing Co., 617A Forest Rd., London E. 17, England.

Instrument Society of America: Journal (called I. S. A. Journal)
Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Pa.

Journal of Applied Mechanics
American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

Journal of Applied Physics
American Institute of Physics, 57 E. 55th St., New York 22, N. Y.

Journal of Scientific Instruments
Institute of Physics, 47 Belgrave Square, London, S. W. 1, England.

Journal of the Aeronautical Sciences
Institute of the Aeronautical Sciences, 2 E. 64th St., New York 21, N. Y.

Machine Design
Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio.

*Mechanical Engineering
American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

*Mesures et Controle Industriel
79, Avenue des Champs-Elysees, Paris (VIII^{e}), France.

National Electronics Conference: Proceedings
National Electronics Conference Inc., 84 Randolph St., Chicago, Ill.

L'Onde Electrique
Société des Radioélectriciens, 10 Avenue Pierre-Larousse, Malakoff (Seine), France.

Prikladnaia Matematka i Mekhanika
Four Continent Book Corp., 38 W. 58th St., New York 19, N. Y. (importers from the U.S.S.R., provide subscription service).

Product Engineering
McGraw-Hill Publishing Co., Inc., 330 W. 42nd St., New York 36, N. Y.

Regelungstechnik
R. Oldenbourg-Verlag, Berlin N. W. 7, Clara-Zetkin-Str. 62, Germany.

Review of Scientific Instruments
American Institute of Physics, 57 E. 55th St., New York 22, N. Y.

Revue Générale d'Electricité
12 Place Henri-Bergson, Paris (VIII^{e}), France.

Society of Instrument Technology: Transactions
80 Bishopsgate, London E. C. 2, England.

*†Taylor Technology
Taylor Instrument Companies, Rochester 1, N. Y.

Wireless Engineer
Dorset House, Stamford St., London S. E. 1, England.

Zeitschrift für Angewandte Mathematik und Mechanik
Akademie-Verlag, GmbH., Berlin W8, Mohrenstrasse 39, Germany.

*These periodicals, although they do not appear statistically in the list arbitrarily compiled as indicated, often carry articles important to control engineers.
†House organ.

ABSTRACTING SOURCES

Another way to keep abreast of the significant literature on control is by systematic scan of abstracts. The author's experience is that most important pa-

pers and books, regardless of the journal or language in which they originate, are eventually abstracted or reviewed in one of the following periodicals:

Aeronautical Engineering Review
Institute of the Aeronautical Sciences, 2 E. 64th St., New York 21, N. Y.

Annales des Télécommunications
Centre National d'Etudes des Télécommunications, 24 Rue Bertrand, Paris (VIII^e), France.

Applied Mechanics Reviews
Midwest Research Institute, 4049 Pennsylvania, Kansas City 2, Mo.

The Engineering Index
Engineering Index, Inc., 29 W. 39th St., New York 18, N. Y.

Industrial Arts Index
The H. W. Wilson Company, 950-972 University Ave., New York 52, N. Y.

Mathematical Reviews
American Mathematical Society, 80 Waterman St., Providence 6, R. I.

Proceedings, Institute of Radio Engineers
1 E. 79th St., New York 21, N. Y.

Referativwyi Zhurnal: Fizika

Referativwyi Zhurnal: Mekhanika
Four Continent Book Corp., 38 W. 58th St., New York 19, N. Y. (importers from the U.S.S.R., provide subscription service).

Revue Générale l'Electricité
12 Place Henri-Bergson, Paris (VIII^e), France.

Science Abstracts—A: Physics

Science Abstracts—B: Electrical Engineering
Institution of Electrical Engineers, Savoy Place, London, W. C. 2, England.

Wireless Engineer (contains abstracts appearing later in Proc. I.R.E.)
Dorset House, Stamford St., London, S. E. 1, England.

BIBLIOGRAPHIES

A rather complete index of the literature can be had by cross-check of the following bibliographies.

1. BIBLIOGRAPHY OF INFORMATION ON SERVOMECHANISMS AND RELATED SUBJECTS, November 1951, 138 pages. Technical Information Bureau for Chief Scientist, Ministry of Supply, London, England. Addendum No. 1, November, 1953, 117 pages.
2. BIBLIOGRAPHY OF LITERATURE ON AUTOMATIC CONTROL: volume 1, edition 1, August 1951, edition 2, November 20, 1952; volume 2, September 30, 1952. Compiled by the Research Group on Automatic Control, Institute of Industrial Science, University of Tokyo, Chiba City, Japan.
3. AUTOMATIC CONTROLS: A BIBLIOGRAPHY; compiled by F. Stenger and R. M. Ancell. United States Department of the Interior, Bureau of Reclamation, Design and Construction Division, Technical Library, Denver, Col., Technical Bibliography 212, 1951.
4. A BIBLIOGRAPHY OF THE FREQUENCY-RESPONSE METHOD AS APPLIED TO AUTOMATIC FEEDBACK-CONTROL SYSTEMS, A. M. Fuchs. Transactions, Society of Mechanical Engineers, volume 76, November 1954, pages 1185-1193; discussion, pages 1193-1194.
5. BIBLIOGRAPHY ON FREQUENCY RESPONSE, Rufus Oldenburger, Chief Mathematician and Director of Research, Woodward Governor Company, Rockford, Ill., April 1953.
6. BIBLIOGRAPHY ON FEEDBACK CONTROL; AIEE Committee Report. Transactions American Institute of Electrical Engineering, Part II, Applications and Industry, Number 10, January 1954, pages 430-462.
7. AUTOMATIC CONTROL BIBLIOGRAPHY, W. F. Wade and E. Kemler. Summary Reports, P. O. Box 176, Spring Park, Minnesota, 1954.
8. ASME TECHNICAL PAPER INDEX on Automatic Control, Automation, and Control Engineering, 1891—July 1954, American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

Stop Coining Words

(continued from page 49)

centuries, and all using the word in its philosophical sense as the antonym of "voluntary."

To sum up, the terminology of automatic production that seems adequate is as follows:

Where there is no program, but repeated action. The control is mostly fixed, as for example in the linked transfer machines:

Generic Noun	*Adjective*	*Verb*
mechanization	**mechanized**	to **mechanize**

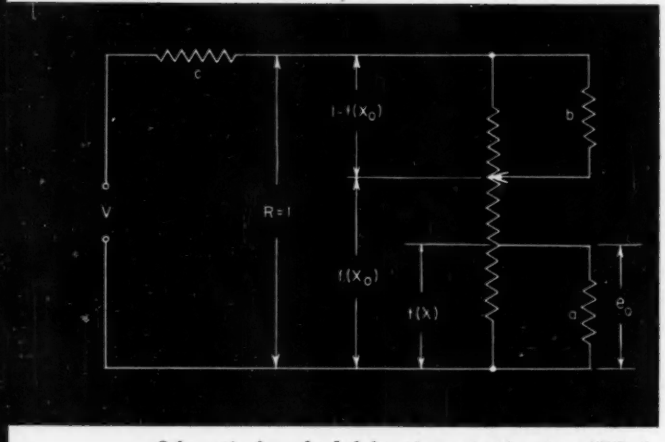
Where there is a program of some kind which causes repeated action. The actions repeated are not the same each time because the sensing devices have brought in information to modify the action:

Generic Noun	*Noun*	*Adjectives*	*Verb*
automatism	**automaton**	**automatic**	to **automatize** or **automatized**

Where records or sensors cause repeated action, but the emphasis is on the control rather than on the output. Here the actions are even less likely to be exactly the same each time, because many sensors have brought in control information to modify them:

Generic Noun	*Adjective*	*Verb*
cybernetics	**cybernetic**	to **cybernetize**

Compensating Function Pots for Loading Errors



Schematic for a loaded function potentiometer. FIG. 1

When a potentiometer is loaded with a finite impedance, the output voltage is no longer the desired function of shaft position. Last month's CONTROL ENGINEERING described a graphical method for selecting compensating resistors for linear potentiometers. A similar method can be used for function potentiometers.

J. GILBERT, The Norden Laboratories Corp.

A FUNCTION POTENTIOMETER has a variable resistance or voltage ratio proportional to some function of angular position, rather than to the angular position itself. A common example is a sine potentiometer, the output voltage is proportional to the sine of the input angular position.

If a finite impedance is applied as a load, the output voltage will not be the correct function of angular position. Adding a compensating resistor is one means of correcting this loading error.

Figure 1 shows a loaded function potentiometer where

a = load resistance or load ratio
b = compensating resistor
c = dropping resistor
$f(X_o)$ = resistance at tap for compensating resistor
$f(X)$ = resistance at wiper of function potentiometer
R = potentiometer resistance (normalized to R equals one)
V = input voltage to potentiometer circuit

The object is to optimize the parameters b, $f(X_o)$ and c so that the loading error ϵ is reduced to a minimum.

It can be shown that the error caused by load ratio a can be expressed by the following relationship where f equals $f(X)$.

$$\epsilon = \frac{f^2(1-f)}{a+f-f^2} \tag{1}$$

or for a greater than ten

$$a\epsilon \leqq f^2(1-f) \tag{2}$$

The maximum error occurs when $f(X)$ is approximately equal to $\frac{2}{3}$. This error is

$$\epsilon_m = \frac{0.148}{a} \tag{3}$$

When c equals zero, the approximate error can be expressed as follows, where f is greater than zero and less than f_o, and u equals b/a.

$$a\epsilon \leqq f^2(1-f) - f(1-f_o)^2/u \tag{4}$$

Referring back to the compensating technique for linear potentiometers (see "Here's a Shortcut in Compensating Pot Loading Errors," CONTROL ENGINEERING, February 1955), it appears that a similar

graphical interpretation holds for Equation 4. Using the linear analysis, let

$$f = f(X) = X' \tag{5}$$
$$f_o = f(X_o) = X_o' \tag{5a}$$
$$u = u' \tag{6}$$

where the primes refer to the parameters of the equivalent linear potentiometer circuit.

From experience gained with the linear case, select

$$X_o' = 0.74$$
$$u' = 0.31$$

Then

$$f(1 - f_o)^2/u = f(1 - 0.74)^2/0.31 \tag{7}$$
$$f(1 - f_o)^2/u = 0.218f \tag{8}$$

and from Equation 4

$$a\epsilon = f^2(1 - f) - 0.218f \tag{9}$$

As in the linear method, Equations 4 and 9 can be interpreted as the difference of two curves, one the uncompensated error curve given by Equation 2 and the other a replica of the original function $f(X)$, whose scale factor is the same slope, $(1\text{-}X_o)^2/u$ as that in the linear example.

Equations 5 and 6 are valid because the loading effect is essentially a resistive effect. Therefore, an identical error should be obtained when the tap X_o for the function potentiometer is located where its resistance, $f(X_o)$, is equal to the resistance at the top, X'_o, of the linear potentiometer. Similarly the compensating resistor ratio, u, must be the same for both cases.

The resultant errors for the loaded function potentiometer can be obtained by plotting Equation 9 directly, or by interpreting the plot of a linear unit in terms of Equations 5 and 6. The latter procedure is followed in Figure 2 for the function

$$f(X) = \sqrt{X}$$

Then from Equation 5

$$X = (X')^2$$
$$X_o = (X_o')^2 = 0.548$$

A typical construction is shown by the dotted lines for X' equals 0.85 and X equals 0.723. The graph shows that the maximum errors are the same as for the linear case, but occur where the corresponding abscissas are squared.

Once the optimum design for the equivalent linear case is fixed, there is no need to plot the loading errors. The designs are given by Equations 5 and 6 directly.

Then for all circuits where c equals zero,

$$f(X_o) = 0.74, \qquad u = 0.31$$

If c equals zero and $f(X)$ equals sinX, then

$$X_o = \sin^{-1}, 0.74 = 47.73 \text{ deg}$$

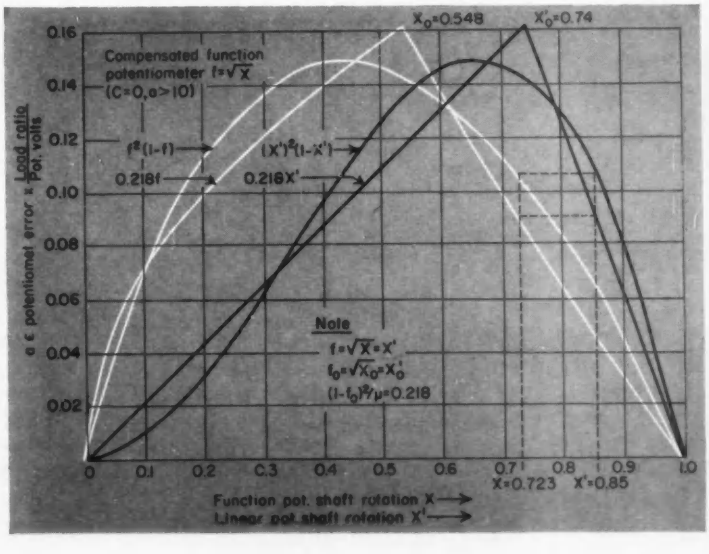
and since X was normalized at unity for 90 deg,

$$X_o = \frac{47.73}{90} = 0.530$$

It can be shown that the compensated linear designs apply to all loaded function potentiometers as well. But the transformations must be made from the equivalent linear circuit.

Remember that both the rotation X and the function $f(X)$, were assumed to be normalized at unity and to start at zero. Hence, make allowance for those functions where $f(o)$ is not equal to zero.

The tolerances for each function considered need individual attention. In any case, the theoretical maximum error, ϵ_m, should be of the order of the limiting potentiometer resolution.



Graphical method for determining optimum compensating parameters for loaded function potentiometers. FIG. 2

THE GIST—The initial article of this series dealt with, first, unregulated behavior. Then it introduced the fundamental requirement of control —maintenance of a dynamic balance between supply and demand through regulation of the supply source.

This second article considers the performance of a plant under the influence of manual and automatic control. As before, we concentrate on controlling the level of a storage tank, only to project theory onto a plane of practice.

In the cases studied you will see that the graphical method has remarkable flexibility, enabling you to trace through the histories of particular plant operations — startup, on-stream, and shutdown. Restriction to simple transients is made for the sake of clarity. The method handles far more complex conditions.

How to Analyze Control Systems Graphically—PART II

H. M. PAYNTER, Massachusetts Institute of Technology and Pi-Square Engineering

The control task breaks down into three parts:

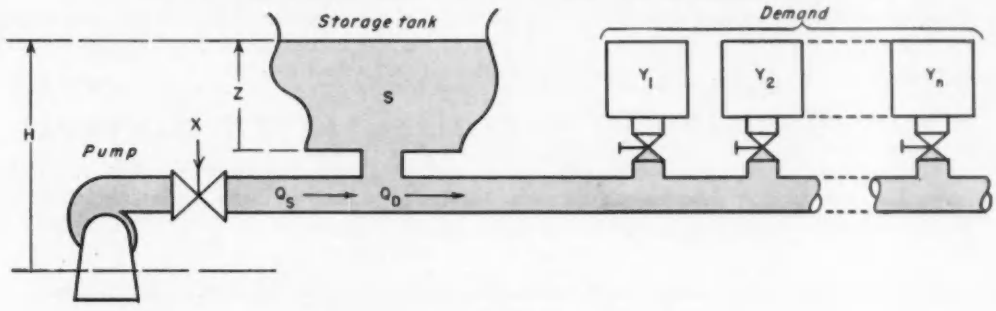
STARTUP. A satisfactory control system must establish the tank level, Z, at a command level, Z*, regardless of the level existing when the plant is closed down.

ON-STREAM OPERATION. The control must maintain the level within prescribed tolerances in the presence of substantial random variations in demand flow, Q_D.

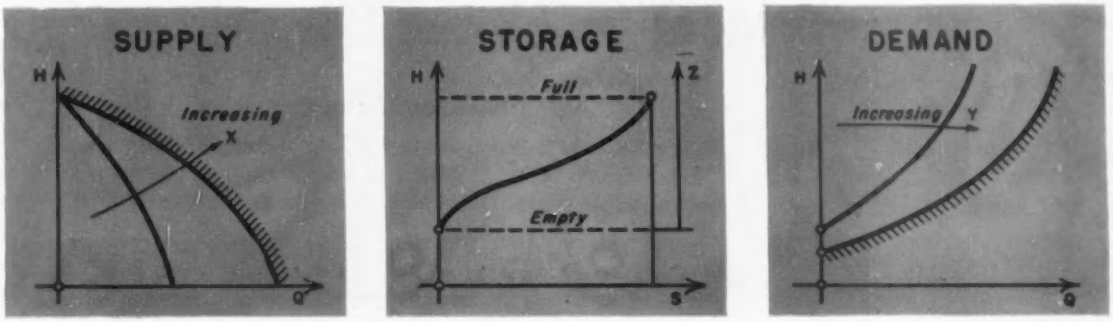
SHUTDOWN. The controller must be able to shut down operations in emergencies or under normal maintenance or production schedules. This involves reducing the flow (usually to zero) and dropping the level to a prescribed minimum by fully closing the supply valve.

We have realized in the first article that, no matter how the level is controlled, fluctuations always occur with variations in the process demands because of dynamic interactions in the system itself and in the associated control components. However, by proper

PROCESS TO BE CONTROLLED . . .

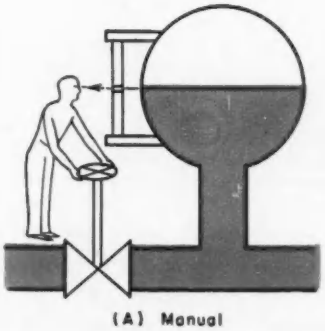


. . . And its Characteristics

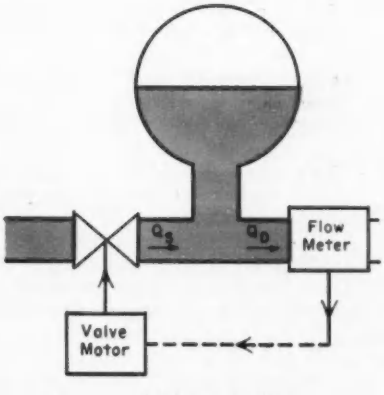


The plant or process consists of the elemental components sketched at the top. The characteristic curves shown below govern its performance. Note, in particular, the demand characteristics shown at the bottom right. They demonstrate the sensitivity of flow to Y, the number of plant units on line, and to tank level, Z, or head, H.
FIG. 1

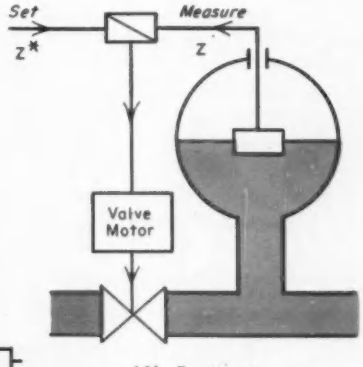
3 TYPES OF CONTROL FIG 2



(A) Manual



(B) Compensation



(C) Feedback

design of the control system, it is always possible to hold a fluctuation, ΔZ, within specified limits. Now consider methods of controlling storage-tank level.

MANUAL CONTROL

In the simplest and most apparent way we could install a gauge glass on the tank and assign an attendant to watch the level and manipulate the supply valve accordingly. This is suggested in Figure 2A. However, the assignment would require constant attendance at the valve if the demand flow, Q_D, varied continuously. The cost, inconvenience, and, in many cases rather poor performance of manual control has led to the use of mechanisms for automatic regulation and control.

COMPENSATION CONTROL

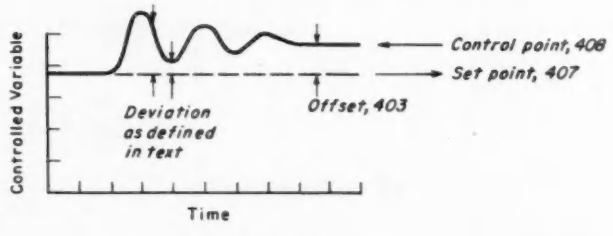
A natural and obvious form of automatic control is the measurement of instantaneous demand flow, Q_D, and the use of the resulting signal to position

---

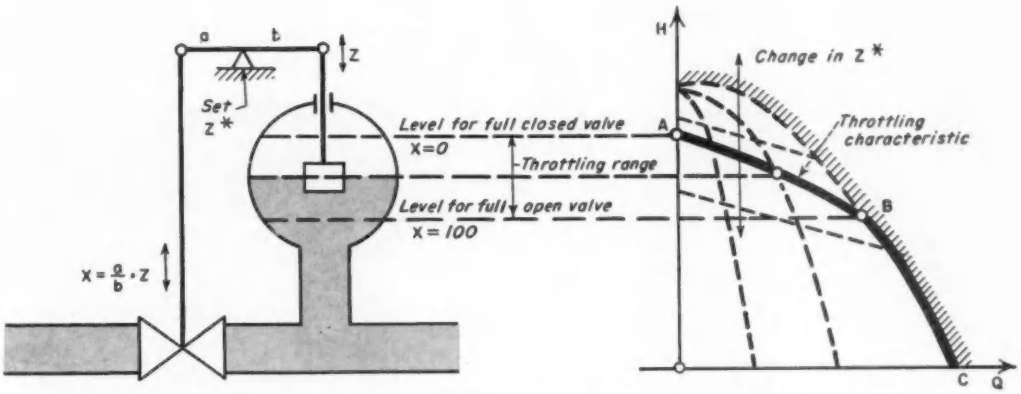
TERMINOLOGY

Some of the symbols and terms used by the author do not quite follow those recommended by ASME and AIEE. Rather than force them into conformance, we offer translations:

Author	ASME Number, Term, Definition
Command Level, Desired Level, Set Level, Z*	407, The Set Point is the position to which the control-point-setting mechanism is set. (See figure)
Measure (ment)	408, The Control Point is the value of controlled variable which, under any fixed set of conditions, the automatic controller operates to maintain.
Offset	403, Offset is the steady-state difference between the control point and the value of the controlled variable corresponding with the set point.
Plant, Process	301, A process comprises the collective functions performed in and by the equipment in which a variable is to be controlled.
Proportional Band	603, Proportional Band, applying to proportional-position controller action, is the range of values of the controlled variable which corresponds to the full operating range of the final control element.
Rate Action	503a, Rate Action is that in which there is a continuous linear relation between the rate of change of the controlled variable and the position of a final control element.
Reset Action Integrating Action	502a, Reset Action is that in which the final control element is moved at a speed proportional to the extent of proportional-position action. This term applies only to a multiple action including proportional-position action.



"Extracted from Automatic Control Terminology, with the permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y."



A float connected to the valve stem moves the valve stem an amount proportional to the change in tank level. FIG. 3

The throttling characteristic is obtained by plotting the valve position, *X*, corresponding to a level, *Z*, or associated head *H*, on top of the supply characteristic. The valve proportions flow only between A and B. Beyond B the valve is fully open and the throttling characteristic traverses the supply characteristic curve, B-C, for a fully open valve. FIG. 4

the supply valve, thus attempting to hold the supply flow equal to the demand flow at all times. If done with absolute precision, no change in tank level occurs, because there is no change in storage volume in the tank. This scheme, indicated in Figure 2*B*, has come to be called compensation control. The oldest form of automatic control, it is commonly used to compensate for temperature changes the escapements of clocks and watches, for example.

For absolute control of tank level this scheme requires perfect measurement of the demand flow, Q_D, and exact settings and interconnections of all components. When the system components are not perfectly matched, the tank accumulates slight unbalances, causing the level to drift. This extremely undesirable characteristic of compensation control has prompted the search for other control schemes.

FEEDBACK CONTROL

The most generally articulate method of automatic control arises through the feedback, or closed-loop action demonstrated in Figure 2C. Here we provide ways for:

- measuring tank level, Z, as simply and accurately as is practical,
- comparing measured level with desired level, Z*,
- and supplying to the valve-positioning motor a signal that is some function of the level error, or deviation between the desired and existing values.

In a rudimentary case of valve stroke X and the deviation, ΔZ, are proportional. More elaborate forms involve rate response. And others include reset or integrating action for level control in the steady state without offset; for as long as the level, Z, differs from Z*, the integrating action moves the valve, attempting to bring them together.

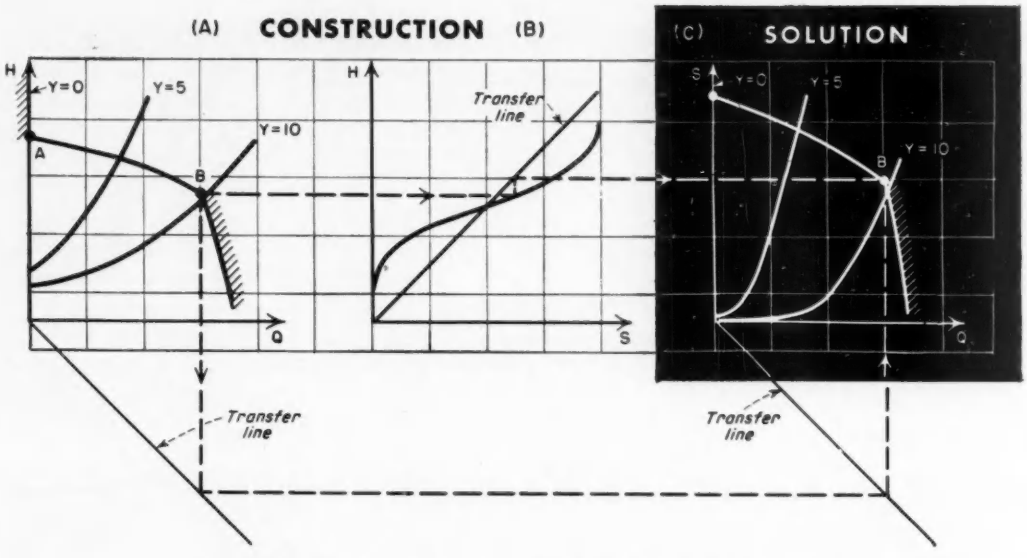
Figure 3 shows the use of a float for proportional control. The float provides force to open and close the control valve. Such direct-connected floats are in common use and are altogether effective for many applications. The first examples consider the behavior of one in controlling level.

Because the float is directly connected to the valve stem, X is proportional to Z by the lever ratio, *a*/*b*. It is clear that a change in level, ΔZ, must occur to drive the valve from the fully open to the fully closed position. Thus a throttling range, or proportional band, must exist for the control to function at all. One might, at first thought, presume that the band may be made arbitrarily small by increasing the lever ratio, *a*/*b*. But, the force available to move the valve also decreases in direct proportion. Therefore, it is not possible to reduce the throttling range below a minimum value at which there is still sufficient force to move the valve.

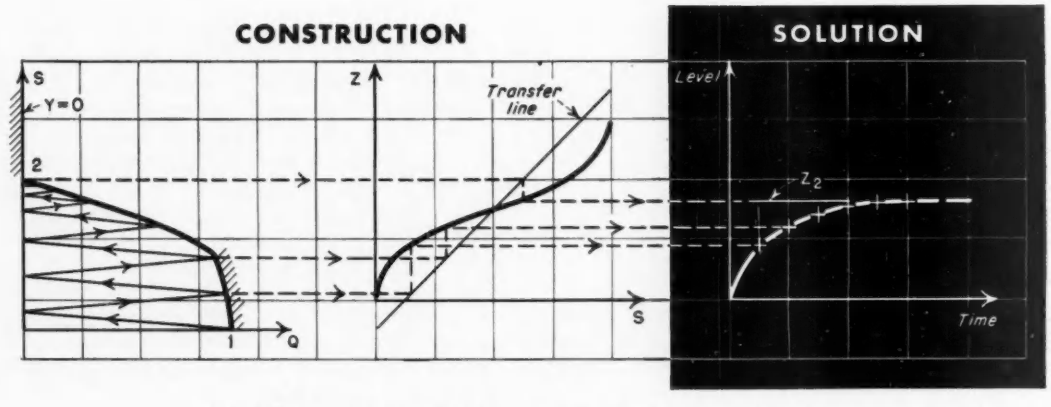
For the supply characteristic, we have now to consider only the resultant throttle characteristic, shown in Fig. 4 and repeated in Fig. 5a. Considering Y, the measure of demand, as the number of processing units in service at any time, the demand curves for varying Y are plotted on top of the supply characteristic in Figure 5a. To simplify analysis the composite supply and demand characteristics are then transformed from head-flow coordinates to storage-flow coordinates through the head-storage relationship for the tank.

FOUR PROGRAMS

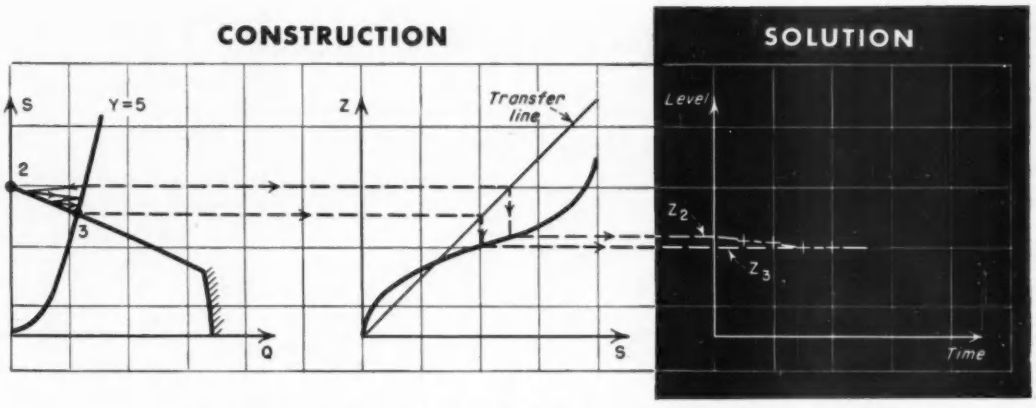
Now follow the plant operation under the control of the device shown in Figure 3. Initially all processing units are shut down, so that Y =O. The pump is disconnected; the pump motor is shut off; the pump is at rest; and the set value of level, determined by the height of the fulcrum shown in Figure 3, is set below the bottom of the tank. Thus the tank is empty and the valve is closed.



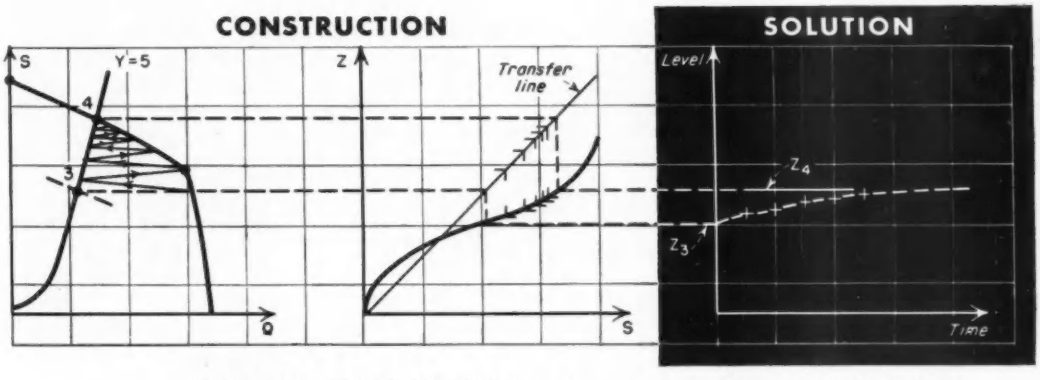
COMPOSITE SUPPLY AND DEMAND—The head-flow characteristics of supply and demand are plotted in 5a. Transformation of point B from the head-flow coordinates to the storage-flow coordinates demonstrates how the complete set of curves is transformed to 5c. $Y = 0$ means that all units are off the line. $Y = 5$ indicates that 5 units are in service. $Y = 10$ signifies that the full-plant capacity of 10 units are on stream. FIG. 5



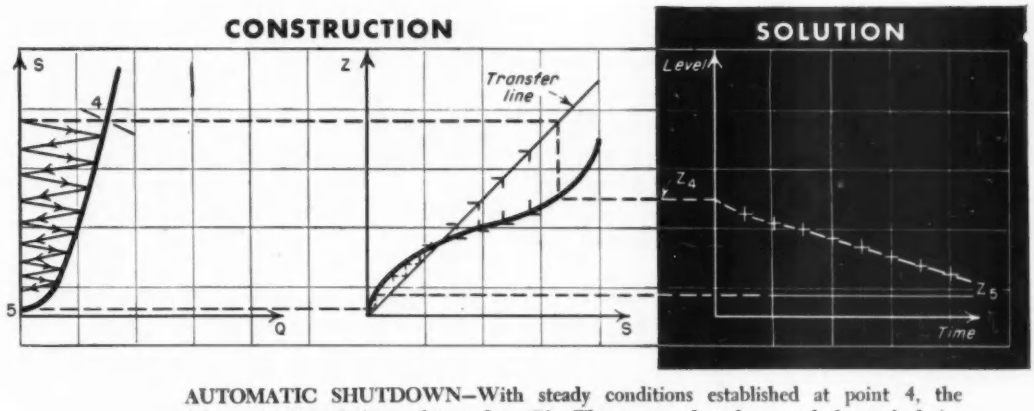
AUTOMATIC START UP—The pump motor is started, bringing the pump up to speed with the supply valve closed. Set level, Z^*, is then abruptly moved to a point corresponding to the tank's mid-level. The ensuing automatic startup, consisting of charging the tank, is reckoned graphically by drawing the slopeline integration between the supply characteristic for midlevel and the demand characteristic for all units off the line, that is, for $Y = 0$. Transformation through the head-storage relationship produces a plot of level vs. time. The time to equilibrium for startup is thus directly determined. The elapsed time depends on the tank's volume, the maximum supply flow available, and the shape of the throttling characteristic. FIG. 6



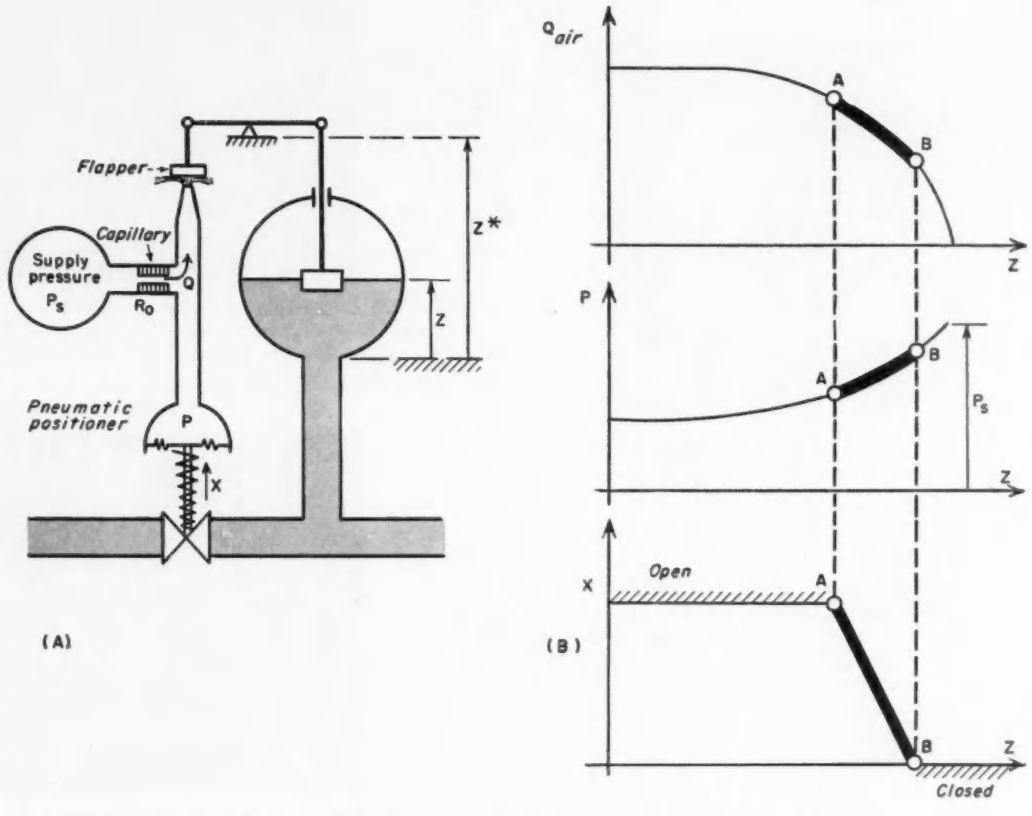
AUTOMATIC ONSTREAM OPERATION—With equilibrium established at point 2 after startup, five units are put on stream. The slope lines integrate graphically between the supply throttling characteristic for midlevel and the demand characteristic for $Y = 5$. The level falls so that supply may balance demand at point 3. FIG. 7



AUTOMATIC LEVEL CHANGE. To raise the level, the fulcrum of the float-actuated control is raised further. The slopelines integrate between the supply throttling characteristic for the new set level and the demand characteristic for $Y = 5$, tracing the actual course of the storage from point 3 to point 4. The transient plotted in 8 is similar to that in 6 because it, too, involves charging the tank. Note that the detail shape of the transient is not the same. Nor is the time-to-equilibrium the same because the valve remains fully open longer. FIG. 8



AUTOMATIC SHUTDOWN—With steady conditions established at point 4, the fulcrum is abruptly lowered to reduce Z^*. The pumps shut down and the tank drains with the five process units still in service. Consequently the slopelines integrate between the supply characteristic for zero desired level and the demand characteristics for $Y = 0$. The shape of the level-time curve and the time to reach effective equilibrium are materially different from the other three cases. FIG. 9



A level change, ΔZ, produces a change in the position of the flapper relative to the nozzle discharging air. The top curve is a graph of air flow rate versus measured level. A central air source supplies the air flow at pressure P_s through a capillary of resistance R_o. The pressure P back of the nozzle and above the positioning diaphragm is varied by the level, Z, as shown by the middle curve. As soon as the pressure falls, the spring-loaded diaphragm raises the valve stem. Eventually the pressure falls low enough to fully open the valve. This occurs at point A on each curve. The fully closed position and corresponding lowest nozzle air flow occur at point B on each curve. The resultant curve of valve position, X, against level, Z, is like that for the mechanical linkage shown in Figure 3. However, it is now possible to have full valve stroke correspond to almost arbitrarily small changes in level, Z. FIG. 10.

PNEUMATIC CONTROLLER

We have observed that the direct mechanical linking of the float to the discharge valve requires an appreciable throttling range, because the mechanical effort to move the valve must come from the float itself. To overcome this disadvantage and still retain reasonable simplicity, it was necessary to develop a power amplifier to put between the tank float and the valve stem. The effort to position the valve then comes from an external energy supply. The general arrangement of such an amplifying actuator is shown in Figure 10, in the form of the commonly used pneumatic positioner.

The next article of this series will discuss the use of other positioning devices and other control functions. The series will conclude with applications of the slope-line method of graphical analysis to broadly diversified control-dynamics problems.—Ed.

Is automation in your future?

Any consideration of automation quickly reveals one outstanding fact. It is that success or failure in automation depends to a great degree on the ingenuity and skill of control engineers. Automatic electrical control is the heart of automation.

This explains why capable management invariably brings such talent into consultation in even their earliest exploratory discussions of automation. Why Cutler-Hammer engineers have already assisted in bringing automation to breath-taking reality in such diverse industries as paper, glass, cement, rubber, sugar, steel pipe, wire and automotive.

Cutler-Hammer leadership in automatic electrical control has been recognized and respected over the entire 62 years since Cutler-Hammer pioneered the art with the very *first* automatic motor control feature ever offered by anyone, the no-voltage release in the Cutler-Hammer Bulletin 10 Motor Starter of 1892.

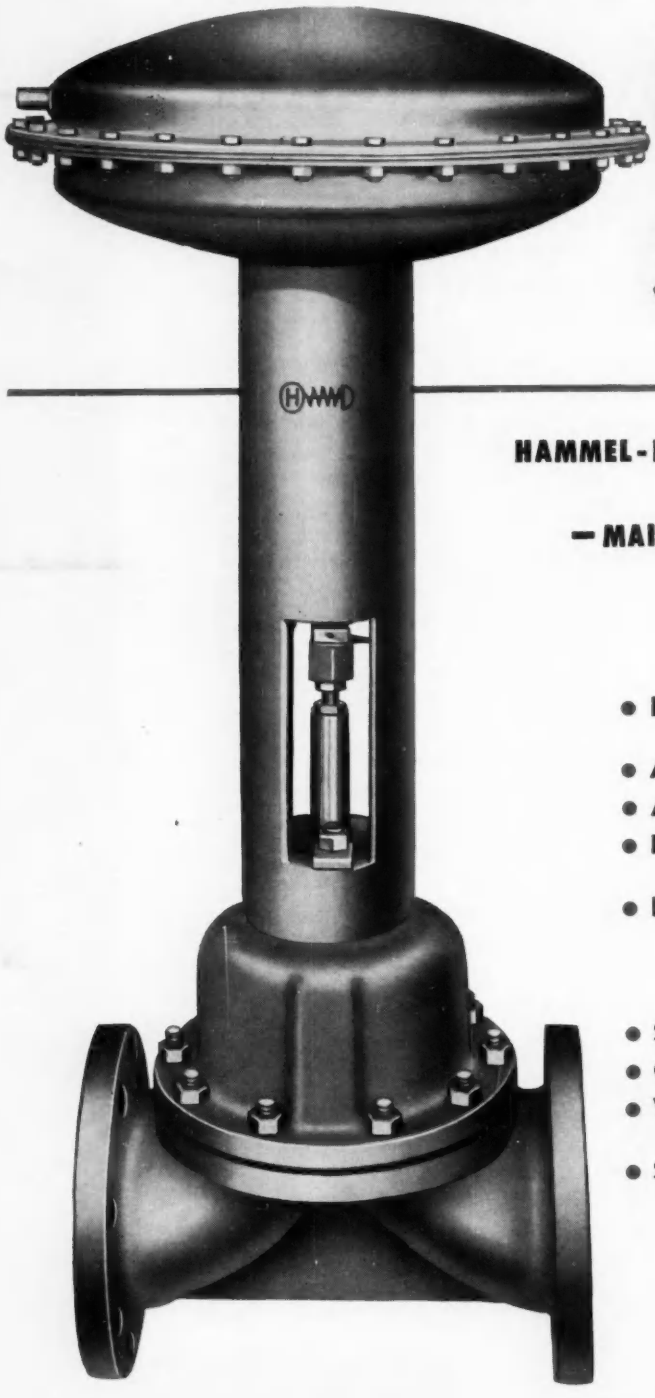
Automation may hold tremendous opportunities for your company in production economies and product uniformity. But it requires a large investment in engineering before a greater investment in equipment. Cutler-Hammer experience can safeguard both. It avoids costly false starts, prevents impractical or needlessly complicated constructions and frequently points the way to unsuspected automation possibilities. Write or wire today. CUTLER-HAMMER, Inc., 1467 St. Paul Avenue, Milwaukee 1, Wisconsin.



The "Kitty Hawk" of Automation

The very first automatic feature in motor control was the no-voltage release in the Cutler-Hammer Bulletin 10 Starter of 1892. The starter handle was held in the "on" position by an electromagnet and returned automatically to the "off" position whenever the power supply failed. This protected men at machines from sudden unexpected restarting, motors against burn-out due to the inrush of uncontrolled current.

CUTLER-HAMMER
MOTOR CONTROL
C-H



Keeping it SIMPLE

HAMMEL-DAHL MAKES THE SAUNDERS VALVE
AUTOMATIC
—MAINTAINING ITS BASIC SIMPLICITY
and LOW COST

Superstructure

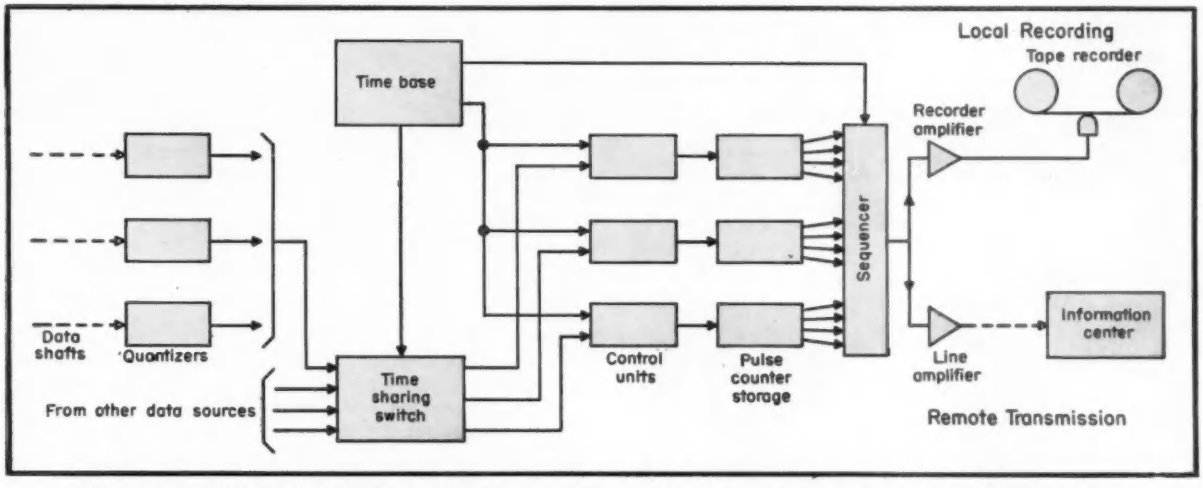
- H-D *ALLSTEEL*
  SECURELY FASTENED TO BODY
- AIR-TO-CLOSE
- AIR-TO-OPEN
- PRELOAD (SPRINGLESS)
  THROTTLING CONTROL
- DUPLEX (SPRINGLESS)
  ON-OFF CONTROL

Body

- SCREWED AND FLANGED ENDS
- GRINNELL OR HILLS-McCANNA
- WIDE VARIETY OF MATERIALS
  FOR BODY, LINING, AND DIAPHRAGM
- SIZES ½" — 10"

COMPLETE
Information in
Bulletin **108**

HAMMEL-DAHL COMPANY
175 POST ROAD, (WARWICK) PROVIDENCE 5, R. I., U. S. A.
SALES OFFICES IN ALL PRINCIPAL CITIES
MANUFACTURING PLANTS IN WARWICK, R. I., U. S. A., CANADA, ENGLAND, FRANCE AND HOLLAND
CANADIAN MANUFACTURING AFFILIATE—GUELPH ENGINEERING CO., GUELPH, ONT.



Main elements of Datatrol. Though the particular system described uses the induction quantizer, digitally sensing the position of a rotating shaft, it can measure and record from any data source if a suitable digitizer is interposed. FIG. 1

Computer Speeds Test-Flight Analysis

For speed, this digital machine goes directly to the source for its data—uses no second-hand information. Result: 200 man-hours of data reduction slashed to one man-hour. In fact, all information is ready for use by the time the flight ends.

A. H. KUHNEL, The Austin Company

Development of pilotless aircraft and guided missiles requires accumulation of data on the dynamic performance of experimental models and production prototypes. Unless this information is precise it may mislead the designers and cause expensive and hazardous delays.

Ordinarily, the craft is tracked by precision phototheodolites with synchronized cameras, from two or more known fixed positions on a triangulation base line. For high-speed aircraft or missiles it is common to make 10 exposures per sec.

For a 5-min. test flight, with the craft tracked by two theodolites and a sampling rate of 10 per sec., the original data consists of two films, each of 10 x 60 x 5, or 3,000, frames. The films could possibly be developed in an hour but usually require a day.

Each individual frame must be examined and information read off and recorded. If the trackers kept the craft within the field of the theodolite at all times, it appears in each frame of the film, together with the dial of a clock and sectors of the azimuth and elevation dials of the instrument. Since the target is rarely centered in the field, the reader must calculate the parallax in azimuth and elevation and correct the dial readings accordingly for each of the 6,000 frames before entering the data in the log. It is conceivable that a skilled reader could record a frame a minute. At this rate it would require 100 hr to transcribe the information from the film.

TAKING A FIX

Correlation of the data then gives the values of azimuth and elevation of the target from each of the two instruments at the same instant. Since the base line between the instruments is known, triangulation yields the position of the target from some reference point at that instant of time. When these calaculations have been performed for each of the 3,000 pairs of readings, the flight path of the target can be plotted. Assuming that an automatic computer is available to do these calculations, the data must be transcribed into form for automatic insertion into the computer. A realistic time for the manual transcription and checking of the information is 50 hours. If the calculations must be done manually on a desk calculator, which is often the case, the final reduction of this information would require at least 250 hr.

Between 200 and 400 hr. are needed, therefore, to derive the flight path of an aircraft, or missile over a 5-min period by the usual method. This means that, depending upon personnel and facilities available, the nature of the flight path will be known in anywhere from three or four days to three or four weeks after the flight took place. The cost of data reduction alone is between $1,200 and $2,400 for this 5-min test flight.

YOU *KNOW* WHEN TO STOP
When You Use the
New ROLLER-SMITH
ELAPSED TIME METER

Why guess at remaining tube life . . . the right time for maintenance operations . . . or the amount of available operating time on your equipment when the new Roller-Smith Elapsed Time Meters will do the job for you . . . automatically and dependably?

Available to meet MIL specifications in 2½" and 3½" flange diameters, these new meters come in hermetically sealed or in bakelite cases. Highly styled to match other Roller-Smith panel instruments, their smart "modern look" will enhance the appearance of your equipment. Like all Roller-Smith products, the Elapsed Time Meters are precision-built by master instrument-makers with nearly fifty years of experience and know-how.

Elapsed Time Meters of standard ratings are available immediately from stock and are attractively priced. Write, wire or phone for quotations and complete data.



NEW "WRAP AROUND" SHROUD

with gasket seal makes these meters as modern in appearance as they are dependable in performance. Precisely built, their neat functional form expresses the forward thinking of our engineers.

ROLLER-SMITH
Instrument Division
CORPORATION
1825 WEST MARKET STREET BETHLEHEM, PENNSYLVANIA
Precision Products Since 1908

See this and other outstanding Roller-Smith products featuring the "new-look" at Booth 702 I. R. E. Show, Kingsbridge Armory, New York City, March 21-24, 1955.

The system called Datatrol acquires the same information fully automatically, using one radar set in lieu of two phototheodolites as the minimum tracking equipment. The use of radar has distinct advantages. Radar measures the distance to the target as well as the angles, thus eliminating the need for triangulation. Radar signals can penetrate clouds and are equally effective at night, thus making the scheduling of tests free of weather and time of day. Radars are equipped also with automatic tracking circuits, so that the target is automatically centered in the radar beam at all times.

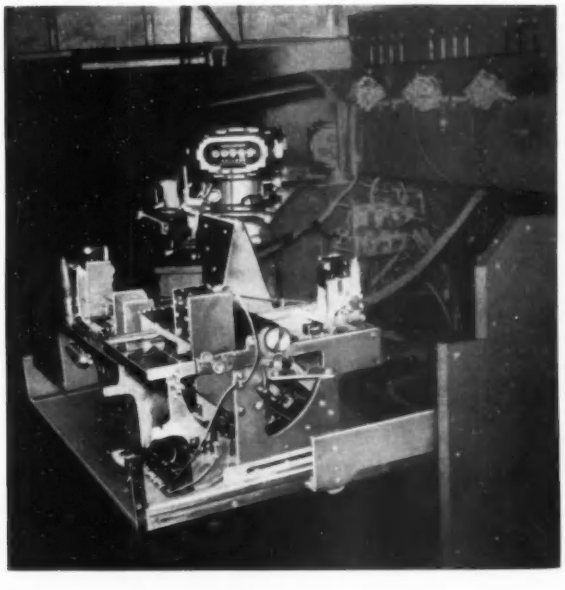
Test flight information is given to Datatrol as pulse trains from three shaft-position quantizers (see CONTROL ENGINEERING, November, 1954) that are coupled directly to the range, azimuth, and elevation shafts of the radar. Every 0.1 sec, Datatrol simultaneously reads the position of the three radar shafts and memorizes this digital information. Immediately after the reading, the time of reading and the instantaneous values of the three coordinates of target position—range, azimuth, and elevation—are read out of the memory in serial form, digit by digit, and recorded on tape.

The system is so programmed that the entire block of information has been read out of the memory and the memory cleared a few milliseconds before the next reading. The entire cycle of reading out the quantizers, storing the data in the memory in parallel form, reading out of the memory in sequential form and recording on the tape takes place in about 96 millisec.

At the end of a 5-min test flight, the 3,000 points in the flight path have already been recorded on magnetic tape and are ready for transcription. The coding is arranged and the recording process designed to be compatible with further steps in the data-reduction process. If a printed log sheet of the test flight is required, it is necessary only to play back the tape through a transcriber unit that controls an automatic printer or typewriter. The playback speed is adjusted to suit the speed of the printer. The tape can be played back through a transcriber that automatically controls a card-punching or tape-punching machine for input to a computer.

Ticket Printer Consolidates Three Loading Records

VERNON KLEIN, Great Lakes Pipe Line Co.



A consolidated printer developed by Great Lakes Pipe Line Company records the delivered volumes of any three products assigned to a loading rack. By printing the three records simultaneously on a single bill of lading, it has accelerated the loading of petroleum products into motor transports. Formerly, loading operations were geared to the output of a single meter because the bill of lading could not be moved from one meter printer to another while product was flowing.

Because the printer was not commercially available, instrument designers in the pipe line company's laboratory designed and built it themselves. The ticket printer consists of electronic counters coupled with an electro-mechanical printing mechanism that prints out the numbers displayed on the counters. Standard Berkeley Scientific Company decimal counters are arranged in three banks of four counters each. The maximum count per bank of 9,999 gallons is adequate, as a total truck load seldom exceeds 6,000 gallons.

Inputs to the electronic counters come from MicroSwitches actuated by cams added to the existing meters on the truck loading rack. Each switch produces one electrical impulse per gallon of produce flowing through the meter. The electrical impulses from each meter are counted by its corresponding counter, and the number at shutoff is retained to actuate the printing mechanism when loading from all three lines is complete. Three selector switches connect any one of the three counter banks to any meter at the loading rack. The setting of these switches also sets up the printing mechanism to print, besides the load figure, three characters identifying the loading spot, the meter, and the product. A clock incorporated in the device prints the time at loading.

The counters are reset to zero automatically when the next bill of lading is inserted. Automatically positioned between cycles to receive the starting and final prints, it is released after the final print. The machine retains a record of all prints for permanent filing.

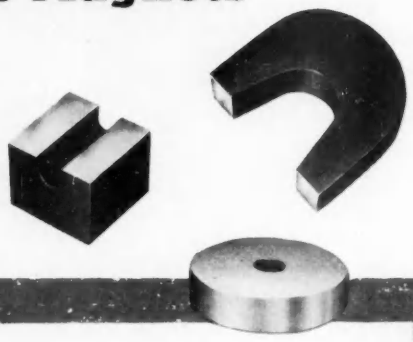
a message

to Original Equipment Manufacturers Who Use Permanent Magnets



May we have 1 minute and 2 seconds to tell you why Indiana Steel Products Company can do the best job, and the most thorough job, of supplying your permanent magnet requirements?

HERE ARE 5 REASONS:



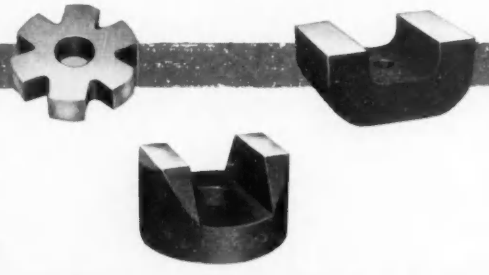
FIRST . . . we're specialists. Indiana Steel Products Company has concentrated on manufacturing permanent magnets for more than 45 years! Attention and interest are not spread over many different and unrelated products.

SECOND . . . all Indiana salesmen are trained *engineers*. In many cases, they can give on-the-spot assistance with immediate problems . . . no delay while they check with the home office.

THIRD . . . Indiana sales engineers draw on our company's 45 years' experience in designing and producing permanent magnets for every conceivable type of application. More often than not, he has *already* encountered problems similar to yours.

FOURTH . . . competently staffed local offices, with direct communication with the home office, assure you of the best possible service . . . expedite rush and emergency deliveries, when necessary.

FIFTH . . . Indiana salesmen are backed by the World's largest engineering staff devoted solely to the design and application of permanent magnets . . . and the World's largest and most complete magnetic research and production facilities.





DO YOU ANTICIPATE a need for magnets in your experimental work, or for use around the plant? Catalog #11-P3 lists a wide assortment. Drop us a line . . . we'd like to send you a copy.

INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY
World's Largest Manufacturer of Permanent Magnets
VALPARAISO, INDIANA

Computing Amplifier Subs for Servo Amplifier

JOHN H. HOSEMANN and ALVIN D. PENDLETON, Clevite-Brush Development Co.

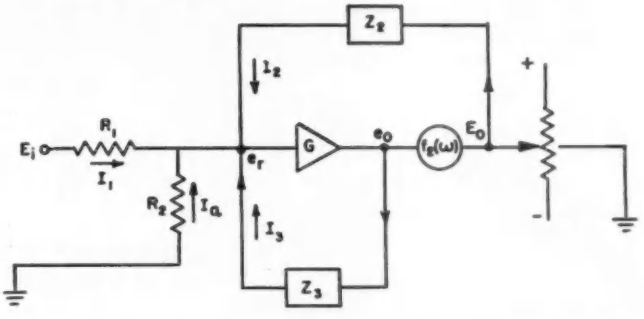
THE PROBLEM: The development of a wide-band dc servo emphasizes certain amplifier problems that don't often arise in a narrow-bandpass system. The coupling of high gain with stability assumes greater importance, since usually a chopper or other highly stable modulating device is not feasible. For example, in attempting to use a high carrier frequency, it is difficult to design and construct a highly stable modulation and demodulation system as well as being difficult to generate high power from an electronic oscillator. In addition, the design of an all-electronic modulator presents the same stability problems as that of a stable dc amplifier.

AND THE SOLUTION: Chopper-stabilized computing amplifiers have now satisfactorily combined high loop gain and dc stability. But these amplifiers are normally operated at a closed-loop gain of about ten. This is many times smaller than the gain required in a servo system.

Consider a servomechanism as a black box with an input terminal and an output terminal that is tied to the tap of the follow-up element. Normally this "black box amplifier" is operated at or near unity gain. This is the condition for which chopper stabilization is most effective. Therefore, this well-known technique can be adapted to a wide-band servo amplifier system. Additional provisions are necessary for auxiliary feedback paths to prevent blocking of the chopper amplifier whenever the servo is unable to follow the input signal. For example, blocking could occur under unusual slew conditions or when the servo is "pegging." Figure 1 shows a block diagram of a typical system.

The system functions based on this diagram are shown in Table I. In the mathematical analysis, it is interesting to note that if Z_3 is the inverse function of $f_2(\omega)$, then the system has a flat, or optimum, response. However, consideration must be given to the phase relationship between the input voltage to Z_3 and the output voltage of Z_3. Without proper care the system will oscillate.

This technique of compensation is used easily only if $f_2(\omega)$ contributes a small phase shift. Tests on this system indicate that for large phase changes in $f_2(\omega)$, compensation can be most readily achieved by using feedback from E_o to the input of the amplifier. In this manner, large phase shifts can be compensated without causing amplifier oscillation.



Block diagram of typical servo system using computing amplifier. FIG. 1

In practice R_a does not appear as a component but rather as leakage.

Another interesting feature of the system is that there are two feedback points that can affect system performance. Sometimes it is better to effect all of the phasing relationships in the feedback loop around the amplifier, rather than in the feedback loop around the total system, since this permits gain changes by merely changing the value of the ratio of the input and feedback resistors. Care must also be taken to preclude potentiometer loading by the feedback resistor.

Using this scheme, servos have been constructed (using special actuators) with responses that are flat from dc to 100 cps. The actual open-loop gain has exceeded 5,000,000. This arrangement has been used successfully with various components in the position indicated by $f_2(\omega)$.

Table I—DERIVATION OF SYSTEM FUNCTIONS

$$I_1 = \frac{E_i - e_r}{R_1};\quad I_2 = \frac{E_o - e_r}{Z_2};\quad I_3 = \frac{e_o - e_r}{Z_3};\quad I_a = -\frac{e_r}{R_a}$$

$$I_1 + I_2 + I_3 + I_a = 0$$

$$\frac{E_i - e_r}{R_1} + \frac{E_o - e_r}{Z_2} + \frac{e_o - e_r}{Z_3} - \frac{e_r}{R_a} = 0$$

For gains, G, much greater than one, e_r approaches zero; therefore,

$$\frac{E_i}{R_1} + \frac{E_o}{Z_2} - \frac{e_o}{Z_3} = 0$$

$$E_o = e_o f_2(\omega)$$

$$\frac{E_i}{R_1} + \frac{E_o}{Z_2} - \frac{E_o}{Z_3 f_2(\omega)} = 0$$

$$\frac{E_i}{E_o} = -R_1\left(\frac{1}{Z_2} - \frac{1}{Z_3 f_2(\omega)}\right) \qquad \frac{E_i}{E_o} = -\frac{R_1}{Z_2}\left(1 - \frac{Z_2}{Z_3 f_2(\omega)}\right)$$

For $Z_2 = R_2$ (Z_2 is pure resistance)

$$\frac{E_i}{E_o} = -\frac{R_1}{R_2}\left(1 - \frac{R_2}{Z_3 f_2(\omega)}\right) \text{ (system transfer function)}$$

NEW! ASHCROFT 2½" GAUGE



HAS TYPE 316 STAINLESS STEEL SYSTEM TO WITHSTAND CORROSIVE CONDITIONS

High resistance to corrosion and sustained high accuracy are combined in this new heavy-duty Ashcroft Gauge. The 2½" dial size makes this compact instrument ideal for small tanks and processing equipment where large pressure gauges would be impractical. Bourdon tube (welded at socket and tip) . . . square shank and ¼" male N.P.T. bottom connection . . . geared movement—the entire gauge system is Type 316 stainless steel.

Made in standard graduations from 30 psi through 1,000 psi, this new Ashcroft Pressure Gauge has a black dial with easy-to-read white figures. The drawn steel case and threaded ring are finished in black. Pointer is precision needle type. Every part is designed, tested and manufactured to meet rigid service conditions.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR now has this new Ashcroft Gauge in stock. Let him know your requirements. You can depend on him for experienced counsel and prompt delivery.

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

1850 ASHCROFT U.S.A.

ASHCROFT GAUGES

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

Telegraph Signals Meter Fluid Level

A system designed for rugged electromechanical components sends modified Morse code, relaying digital information that it picks up from a float. The message passes automatically through a receiver and decoder and thence to an indicator or recorder.

ERNST WEBER, Siemens & Halske Aktiengesellschaft

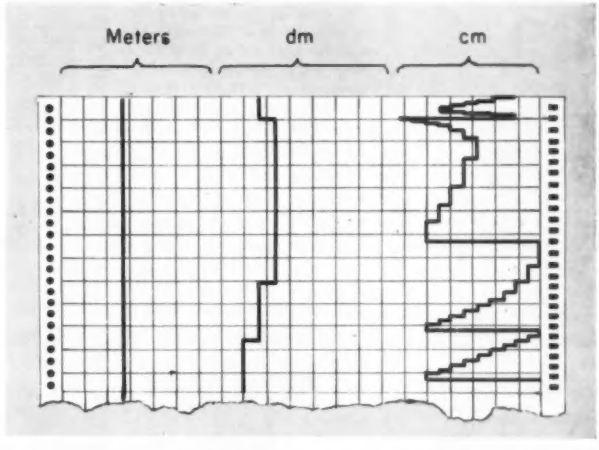
Many industries need to telemeter fluid-level information. And often they must know the level within a centimeter regardless of the measuring range. Thus, if the metering range were 3 meters, the transmitting and receiving elements must be sensitive to 300 units. With amplitude-proportional signals, the loss of energy over long distances would considerably complicate the transmission and receiving apparatus. Within the area of digital transmission systems, a technique using pulse: time signals would either demand extensive transmission time or lessen accuracy. An additive pulse system, in which each fluid level has an associated number of pulses (e.g., a 30 mm level indicated by a 30 cps signal, or simply 30 pulses in an "information group") would call for extended band width. Band width is used here as meaning the total different bits of information in a complete message.

Given the accuracy and speed limitations of simple, rugged, electromechanical components, the best telemetering system will use amplitude changes for values corresponding to only 0 and 1, or an open or closed circuit . Discrimination of time durations with relative magnitudes of 5 to 1 are also well within the capabilities of conventional components. Therefore, it would appear that a system using two conditions of current amplitude (0 and 1) and two time durations of these values (with relative magnitudes of about 5 to 1) would form the most practical basis for a telemetering signal code from the standpoint of accuracy, reliability, and band width.

Suppose that the water level in a reservoir is 300.3 cm. Because of the digital character of our system, a value of 300 cm will be transmitted. If the decimal system were retained for every positional value, three decades (each numbering from 0 to 9) would be transmitted, or a maximum of 30 digits, or 30 pulses. If a system is used where exactly 30 pulses are always transmitted, for the signal with a value of 300, the 4th, 11th, and 21st steps must be somehow emphasized (see Figure 1). The simplest means of emphasis is a long impulse or a long pause at each of these steps.



Code signal containing long pulses for identification of the digits of the number 300. FIG. 1



Output of the system can be converted into different current step values by means of a relay circuit, and the readings read out on a three pen recorder. FIG. 2

The system described here requires the following components: A quantifying and coding pickup, a telegraph sender, a telegraphic receiver, a decoder, and finally, an indicator or some sort of recorder.

QUANTIFYING AND CODING INSTRUMENTS

A float measuring water level moves up or down with changes in the fluid level. Its travel is converted into a rotary motion. This rotary motion can be converted into a digital value by a ratchet or spring detent mechanism, so that a 10-position rotary switch can be operated by the float. Three such rotary switches—corresponding to centimeters, decimeters, and meters —can be operated by a single float.



PRESSURE, TEMPERATURE AND LIQUID LEVEL CONTROLLERS

Leslie Controllers consist of a single or double seated diaphragm control valve operated by a Control Pilot. The latter is an air, water or oil actuated device that produces a variable loading pressure to the valve diaphragm in response to a pressure, temperature or level change in the controlled medium. Controllers are used for any one or any combination of the following conditions:

★ When an exactly controlled level, pressure or temperature is required.

★ When power is needed to assure automatic valve opening after prolonged, tight shut-off.

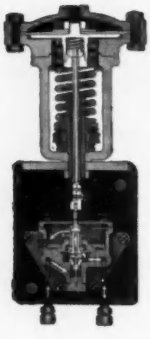
★ When power is needed to operate single-seated valves under high pressure drop.

★ When the available fluid pressure differential doesn't supply enough power for self-operation.

★ When extreme pressure reductions are necessary (i.e. 600 reduced to 10 psi, 900 to 2 psi, 2150 to 5 psi); all can be handled in one step.

★ When fluid contamination requires the simplest type regulating valve for dependable operation.

★ When operation from either a nearby or remote control station is desired.

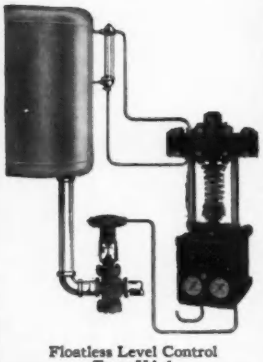


Control Pilot
Type PD

LESLIE
CONTROL PILOTS

Simple mechanical device employing constant supply of clean air, gas, water or light oil at 20-22 psi to produce a variable output or loading pressure of 0-20 psi in response to a level, pressure or temperature change applied to operate a control valve or power cylinder controlling fluid flow.

SEND FOR BULLETIN 5303



Floatless Level Control
Type UA-1

LESLIE
FLOATLESS LEVEL CONTROL

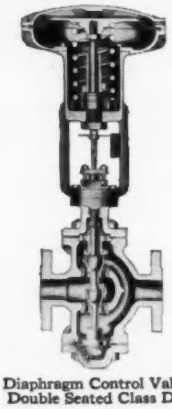
Provides accurate control of liquid level (plus or minus 1" water column). Eliminates problems caused by troublesome linkages, torque tubes, floats and stuffing boxes. Simple design provides steady, positive, precise control even under difficult conditions. Consists of Level Control Pilot and diaphragm control valve.

SEND FOR BULLETINS
5303, 5304, 5305

LESLIE
DIAPHRAGM CONTROL VALVES
(Double Seated)

Flow-line contoured body for high capacity, low pressure drop. Standard ISA face to face dimension in cast iron, cast bronze and cast alloy steels. Renewable, self-aligning guides. ½-10". To primary service rating of 600 psi—950° F. flanged, ring joint and welding ends.

SEND FOR BULLETIN 5305

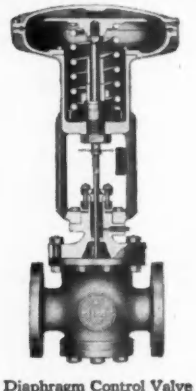


Diaphragm Control Valve
Double Seated Class DV

LESLIE
DIAPHRAGM CONTROL VALVES
(Single Seated)

Control flow of steam, liquid, air or gas. Tight shut-off. Operated automatically by air, water or oil pressure supplied from a Control Pilot or from a loading device such as LESLIE Air Loading panel. Available in unbalanced or fully balanced types, ½-10" in cast bronze, cast iron and cast alloy steels. Primary service ratings to 2500 psi, 1000° F.

SEND FOR BULLETIN 5304



Diaphragm Control Valve
Single Seated Class DL-1

3189

LESLIE CONTROLLERS

SINCE 1900

"STILL FAR AHEAD IN QUALITY AND PERFORMANCE"

LESLIE CO., 211 GRANT AVENUE • LYNDHURST, NEW JERSEY

THE TRANSMITTING APPARATUS

The transmitter has a selector relay, or stepping switch, to whose bank the contacts of the rotary switches are connected. A relay interrupter sets the selector relay in motion. As soon as the selector relay reaches a setting whose connecting contact from a rotary switch is closed, the impulse operates a long-impulse relay to extend the appropriate unit at least four or five times as long as all the other impulses.

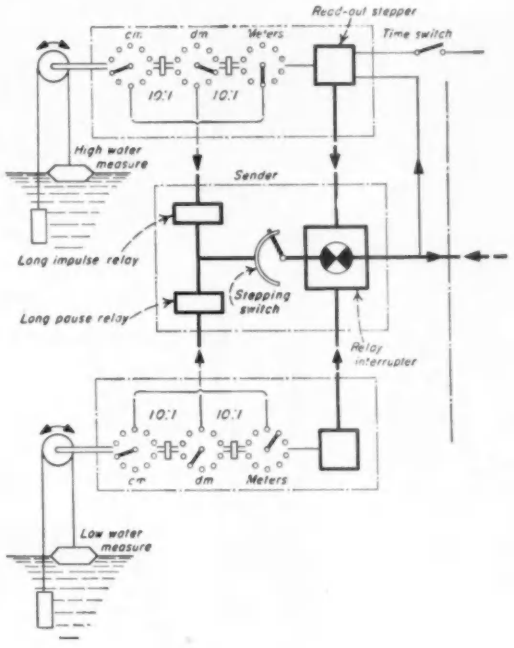
It is possible to build into the system and transmit simultaneously a second set of values. A duplicate pickup for converting float motion into a digital value transmits this value by long pauses.

There are three ways to call on the transmitter system for a "read-out." Any change in water level may initiate read-out; a clock mechanism may regularly activate the system; or a signal may come from the receiver or central station.

THE TELEGRAM RECEIVER

The transmitted impulses activate a selector relay, or stepping switch, in the receiver. A decoding apparatus is connected to the bank of the selector relay. Each step of the selector relay represents a new number. A long-impulse-relay and a long-pause-relay check the lengths of incoming signals. When a long impulse signal arrives, it is channeled to the decoding device.

The receiver does much more than this, however. With the usual receiver, it is difficult to determine whether the measured value as received is correct or not, unless the error is so great that the improbability of the erroneous value is clearly recognizable. When a telegraph system is employed, error is detectable. Every message takes the same length of time and consists of a definite number of steps. The selector relay in the receiver counts the number of steps in conjunction with a cam counter. This constitutes a first method of checking. Further, in the system described here, every "telegram" is characterized by three digits, corresponding to the transmission of three long impulses. When two messages are sent simultaneously there must be three long impulses and three long pauses. The receiver counts them. If either the number of steps is incorrect or a wrong number of impulses or pauses have been received, the receiver "stamps" the message as false. Because by means of a special counting chain built into the Siemens instrument, not only too many long impulses or pauses but also too few are counted, the control of the accuracy of the telegram is quite extensive.



Schematic of transmitter shows how two values are transmitted simultaneously. FIG. 3

THE DECODING APPARATUS

The decoding apparatus is very simple and very certain in its operation. The selector relays of the receiver are actuated by the oncoming impulses and therefore work in synchronization with the selector relays of the transmitter, if the telegram has been correctly received. Decoding the complete message consists of the duplication of the position of the closed contacts of the pickup rotary switch. This can be accomplished by relays that react to either a long pause or a long pulse. To count the digits 0-9 at least nine relays would be necessary. To reduce the number of relays, the dual binary system has been selected over the decimal system. Thus, only four relays are utilized. The value of the measured signal is also stored by the relays until the next signal arrives.

INDICATORS AND RECORDERS

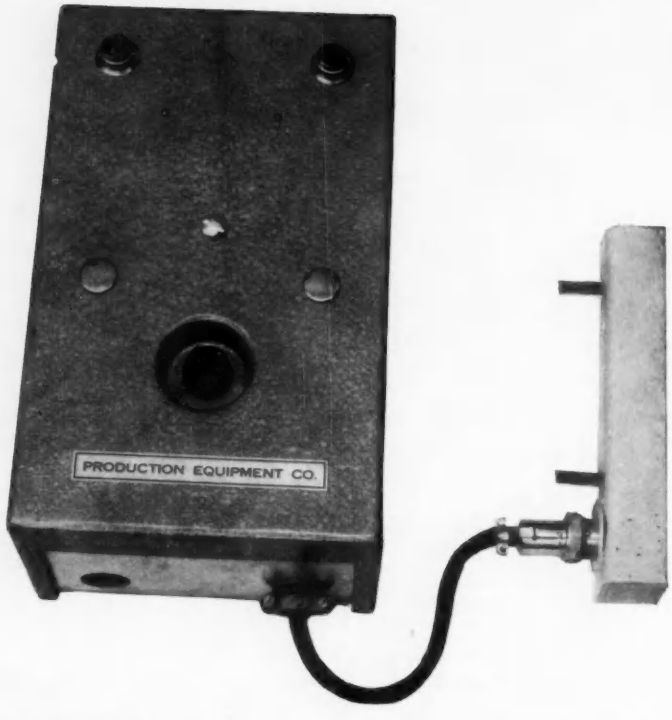
An ordinary pen recorder has an error of 1.5 per cent, while a very good one has errors of 1 per cent. But even with a very good recorder, readings are not easy to take because of the great number of lines required for an accurate reading. A three-pen galvonometer recorder solves the problem of accuracy and legibility. The position of each pen corresponds to the appropriate decimal power, which is produced electrically by reducing, in steps, resistances in series with the recorder's driving current.

FEEDBACK FACT

Posed: Some means to speed-up the throughput of Santa Claus.

Solved: Giftagraph, Inc. has come up with the world's first push-button "Santa". It's like an "Automat" for gifts. The viewer selects, then pays 10 cents for an order form, gift card, and envelope. He slips the needed money into the machine's vault . . . and messengers plus the U. S. Mail do the rest.

NEW PRODUCTS

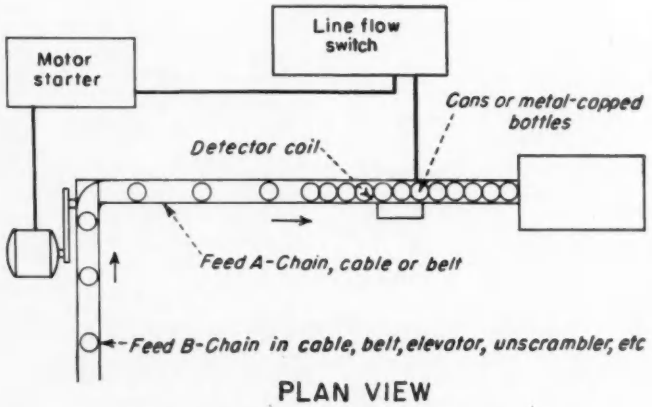


FLOW CONTROL, counting and checking with induction relay for small and large metal parts.

Although analogous in function to a photocell relay setup, this inductance relay "Line Flow Switch" has features that enable it to perform the reverse of indicating the passage of single parts. It can indicate the presence of motionless or very slow moving metal objects. The value of this is shown in the accompanying illustrations. Conveyor or belt systems may cause parts to pile up or become jammed if a temporary bottleneck appears anywhere in a continuous system. The detection of stalled or very slow parts can be used to halt conveyor sections feeding into the blocked section until the "queue" has been cleared.

The Line Flow Switch shown here accomplishes this by means of a built-in delay relay. When the time elapsing between moving parts drops below some set minimum, the relay closes and stops the appropriate conveyor sections or sounds an alarm. Using a thermal differential relay, such as in last month's issue of this section, high and low rates of moving parts might operate appropriate signals or speed drives. This induction relay also has use as a simple count detector, and can operate from parts as small as coat buttons. A 1-in. space between part and pickup is recommended. One especially appropriate use for the relay is in detecting missing bottle or jar caps. Maximum counting rate is 250 per min, with 50 per cent "on" time. *Production Equipment Corp., 111 Ortega Ave., Mountain View, Calif.*

Circle No. 1 on reply card



PLAN VIEW

"Feed B" stops when containers back up on "Feed A". After "Feed A" clears itself, "Feed B" starts again.

LISTING IN GROUPS

1-14 Sensitive Sensors
15-29 Liquids and Gases
30-39 Electro-Mechanical Mechanisms
40-49 Electronics in Control
50-54 Motors and Motion



TEMPERATURE SWITCH has thermometer added.

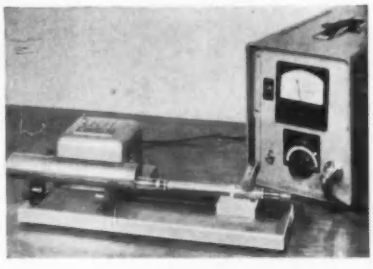
Bimetallic expansion, through levers, operates a snap-action switch in this temperature controller. The dial thermometer is independent of the switch elements. Six temperature ranges are available. *Burling Instrument Co., 16 River Road, Chatham, N. J.*

Circle No. 2 on reply card

ROLLS ALONG sensitively and demonstrably.

Measuring the surface finish of the inside and outside of cylinders is the function of this instrument. The part to be measured is placed on two pairs of rollers, which rotate it at a constant speed of 0.3 in. per sec. Minimum part length is 2½ in.; max. 12 in. Max. OD is 3½ in. *Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.*

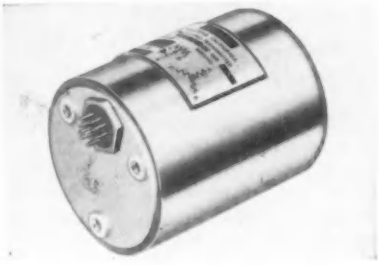
Circle No. 5 on reply card



RATE GYRO is small, adaptable and rugged.

Its case filled with oil, this small Rate Gyro, Model 36128, is built to withstand rough treatment, although only 2 in. dia and 2.68 in. long. Developing an angular momentum of 1,500,000 gm cm²/sec, it displays unusual sensitivity through a precious metal pick-off from a precision winding, or with an induction pot. *G. M. Giannini & Co., Inc., 918 East Green Street, Pasadena 1, Calif.*

Circle No. 6 on reply card



OPTICAL FILTER cut from one large germanium crystal.

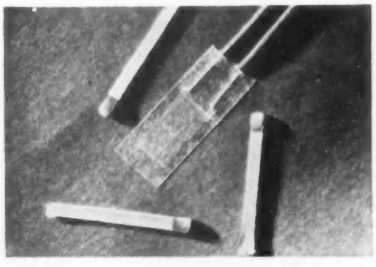
Fabricated from a single highly purified crystal, the Germanium Transmission Filter is 1⅛ in. dia and ⅛ in. thick, ground, polished, and coated on both sides. It transmits both the near and far infra-red regions. *Baird Associates, Inc., 33 University Road, Cambridge 38, Mass.*

Circle No. 3 on reply card

TEMPERATURE SENSOR is postage-stamp-sized.

The RdF Stikon line of resistance thermometer elements has a new addition for the minus 100 to 500 plus deg F range. Postage-stamp size and weight, the resistance of this model at 70 deg F is 100 ohms. Used in a Wheatstone bridge, direct temperature readings are possible. A bulletin is available. *Ruge-De Forest Inc., 50 Moulton St., Cambridge 38, Mass.*

Circle No. 7 on reply card



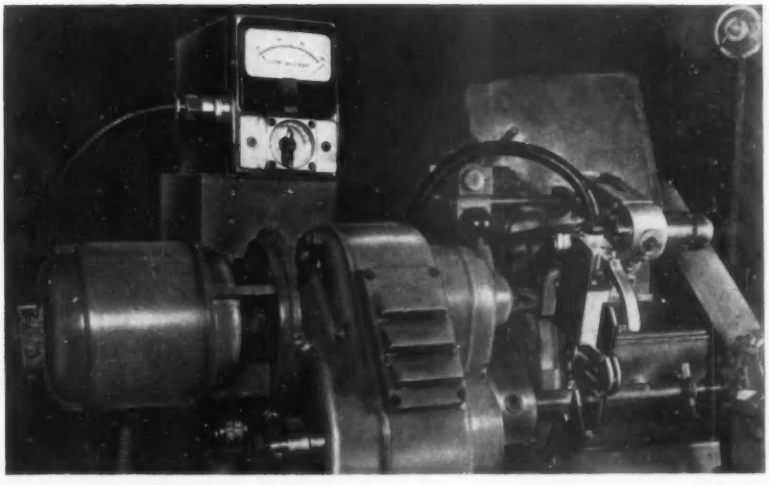
ELECTRONIC MIKE takes over to free top men.

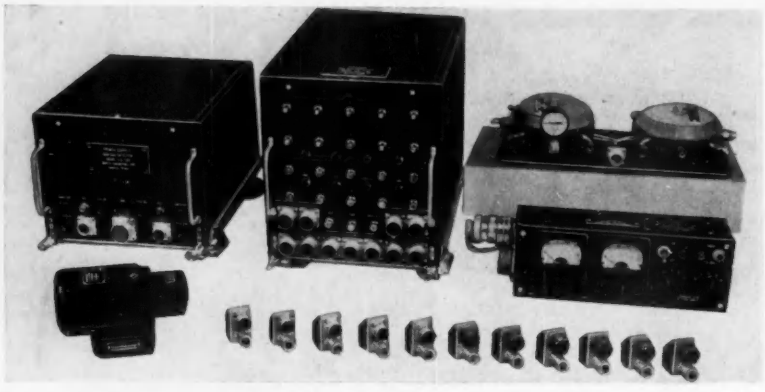
Switch operation moves this electronic micrometer out of the class of complex measurement devices and brings it into the class of simple control elements.

Operating on tolerances of one half of one ten thousandth (0.00005) of an inch, this micrometer gives dial indication of dimension as well as limit-switch action.

The "Autosizer," withstands rough handling and is self-compensating for wear, temperature, and moisture. Setup time is 15 min. *Industrial Gauges Corp., Englewood, N. J.*

Circle No. 4 on reply card



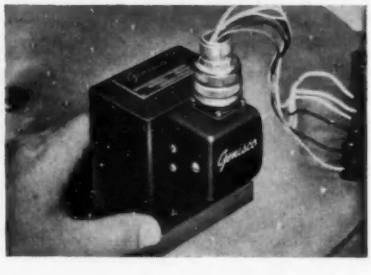


SMELLS EXPLOSIVE gas, warns of dangerous concentrations.

Used for the detection of explosive air mixtures, this instrument works on the principle that a mixture of combustible gas and air will burn in the presence of a platinum filament heated to a temperature which is, nevertheless, not greater than the ignition temperature of the mixture. The temperature of the filament is raised by the combustion, its resistance is lowered, and the resultant voltage change activates an alarm system. Ten relays are used to signal different gas concentrations, and two calibration meters are provided for monitoring gas concentrations at two different points. Time response is less than ½ sec in the standard installation. *Bristol Engineering Corp., Beaver Dam Road and Oak Lane, Bristol, Pa.*

Circle No. 8 on reply card

HEATED ACCELEROMETER provides own constant temperature.



A mass on the end of a parallelogram-type leaf spring coupled to a double-contact potentiometer brush provide almost friction-free motion along this instrument's sensitive axis. Limit stops enable it to withstand 40-g shocks without damage. The potentiometer winding is of platinum alloy wire with a resistance of 14,000 ohms. Its error is within 1 per cent of full scale. The unique feature is a built-in thermostatically controlled heating element, enabling operation between minus 65 deg and plus 160 deg F, for measurements of plus or minus 1 g or 3 g. *Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, Calif.*

Circle No. 9 on reply card



BRIDGE CONTROLLER without usual moving parts.

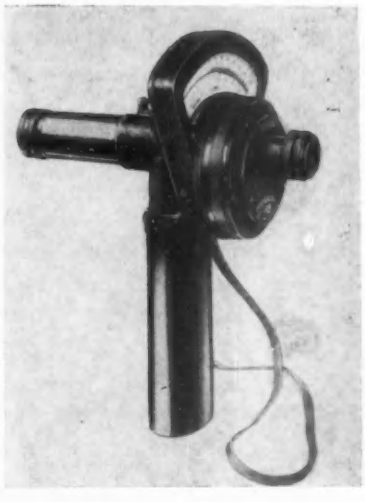
Here's how it works. A voltage from a thermocouple is bridge-balanced against a voltage imposed by the control dial setting. The difference is fed into a saturable reactor, the output of which controls a Thyratron which operates the power relay. *Thermo Electric Manufacturing Co., 501 Huff St., Dubuque, Iowa.*

Circle No. 10 on reply card

PRESSURE SWITCH for 0.01 in. of water.

Two new sensitive pressure switches feature the Mercoid Sealed Magnetic Mercury Switch, for measurements in terms of hundreds of an inch of water. The PQW is intended for out-door use, and has switches, operating through the range of 0 to 0.1 in. pressure or 1 to 30 in. vacuum. Model PQW operates as a pressure difference switch, with ranges of plus or minus 6 or 30 in. of water. *The Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.*

Circle No. 11 on reply card

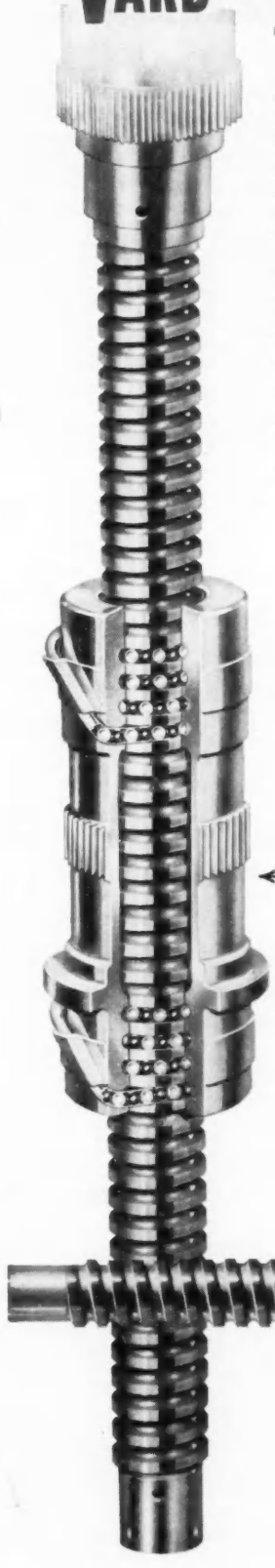


PORTABLE PYROMETER from abroad.

For measurements in the temperature range of 700 to 3,500 deg C is designed this completely self-contained imported instrument. Its operating principle is that of optical comparison, by the operator, of the radiation intensity of an internally glowing lamp filament, powered by a built in storage battery, with that of the surface being measured. A voltmeter dial displays directly the temperature of the filament, and hence that of the measured material. Hartmann & Braun of Frankfurt are makers, and the distributors are *Epic, Inc., 154 Nassau St., N. Y. 38, N. Y.*

Circle No. 12 on reply card

VARD···FIRST IN MECHANICAL ACTUATION



This complete Boeing B-52 Stabilizer Trim Actuator incorporates a 2.87″ P. D. Vard ball nut and screw which is made from 9315 steel carburized to Rc 58 and utilizes multiple circuits of alternate spacer and load balls. The unit also contains 3 gear drives, 2 hydraulic motors, 2 Acme screws and electric and hydraulic actuators.



IN HANDLING YOUR SPECIFIC PROBLEM...

It is possible that one or more of the many types of ball screws now in production at Vard can satisfy your immediate needs.
Our model shop is also in a position to deliver custom units promptly.

Vard engineers will analyze your ball screw requirements to determine the advisability of single or multiple ball circuits. Either of these options may require all load balls or alternate spacer balls. You may be sure that the combination indicated by our analysis will best meet your needs and will be produced by the finest facilities available.

Resident Sales Engineers:
New York City
Dayton, Ohio

VARD

2981 East Colorado Street
Pasadena 8, California

announcing the new

AMPLITROL



PYROMETER CONTROLLER

highly accurate, simple operation, low cost

Here's a new instrument of advanced design for accurate, fully automatic control of temperature in electric furnaces, ovens, other industrial heating devices. The AMPLITROL utilizes the established potentiometer principle, but never needs standardization. No batteries to service . . . no moving parts other than relay contacts . . . immune to vibration, dust and dirt. To operate simply set dial at desired temperature . . . signal lights show temperature condition from long distances. Available in both on-off and proportioning models with wide selection of F. or C. dials. Simplify your control procedures, cut maintenance costs with the AMPLITROL.

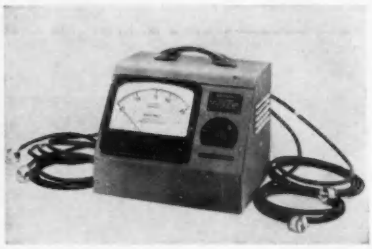
- minimum servicing
- no standardization needed
- no batteries
- highly visible signal system
- easily installed and operated

LOW COST . . . . . $140 and $155

Write for data and dealer's name

THERMO ELECTRIC MFG. CO.
501 Huff St. Dubuque, Iowa

NEW PRODUCTS



THERMISTORS make this monitor keen.

Thermistor probes give this temperature scanner unusually fast response and the ability to measure accurately down to $\frac{1}{10}$ deg F. The instrument shown is set-up for four-point scanning and has a scale span of only 20 deg F. Its thermistors are contained in sealed housings.

We are told that this particular scanner was originally developed for monitoring temperatures during manufacture of lead screws. *Instrument Div., Avionic Products Eng. Corp., Dover, N. J.*

Circle No. 13 on reply card

TEMPERATURE SWITCH is super-sensitive.

A new type of mecurial thermoregulator for precision control of temperatures has an interesting means of precise adjustment. An external magnet rotates in internal armature, which raises or lowers the contact through a micrometer screw. The accuracy of the instrument, as a result, is plus or minus 0.002 deg C. The Magna-Set, as it is called, operates within the range of 35 to 300 deg C, and between minus 60 to 35 deg C. *Precision Thermometer & Instrument Co., 1434 Brandywind St., Phila. 30, Pa.*

Circle No. 14 on reply card

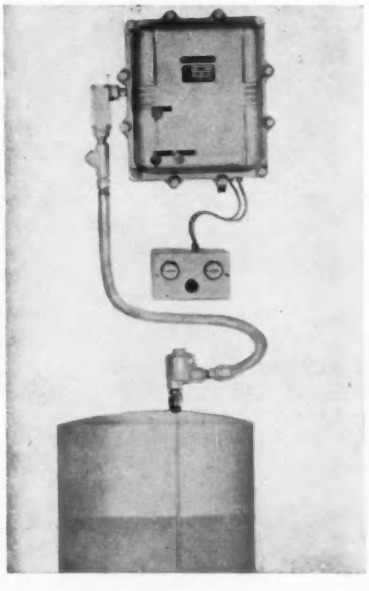
LIQUIDS AND GASES

REBALANCES capacitance bridge with radio frequencies to measure fluid and granular depth.

Using radio frequencies to offset leakage resistance is one feature of a recorder-controller for use where the height of liquids, granular solids, and conducting and non-conducting materials is of interest. Basically, it is capacitance bridge, where the capacitance being measured is one leg and a motor-driven rebalance capacitor is the opposing leg. Any unbalance signal is fed to a phase-sensitive demodulator and converted to a 60-cycle signal, which is then amplified to drive the rebalance motor. Called the Series 42 Recorder Controller, it provides accuracy of $\frac{1}{4}$ of one per cent. *Fielden Instrument Division, 2920 N. Fourth St., Philadelphia 33, Pa.*

Characteristics

Pen speed . . . . . 3.5 sec for full scale
Sensitivity . . plus or minus 0.5 per cent of span
Linearity . . . . . 0.25 per cent
Repeatability . . . plus or minus 0.25 per cent



Circle No. 15 on reply card

HARDENED *and* GROUND

DOUBLE ENVELOPING WORMS *and* Worm Gears

The Vard-designed worm grinder now makes it possible to produce steel double enveloping worms which are ground after carburizing with a contour that cannot be matched by any other method. Carburizing the rough blank also produces a surface hardness of over 60 Rockwell C scale with a depth of .025 to .035 of an inch on the finished worm. The finish maintained is 16 microinches RMS or better. The carburized steel worm also offers high resistance to fatigue failures due to the pre-stressed surface.

INTERCHANGEABILITY

The teeth of the worm gear are cut by a hob which is ground using the same machine setup as that used to produce the worm. This method results in interchangeable parts rather than the lapped, matched sets produced in other types of manufacture.

HIGH EFFICIENCY

The accuracy attained by the exclusive Vard process provides a combination of true geometry and surface hardness that assures higher efficiency for longer periods of time than comparable gear sets fabricated by other methods.

ACCURACY AND CONTROL

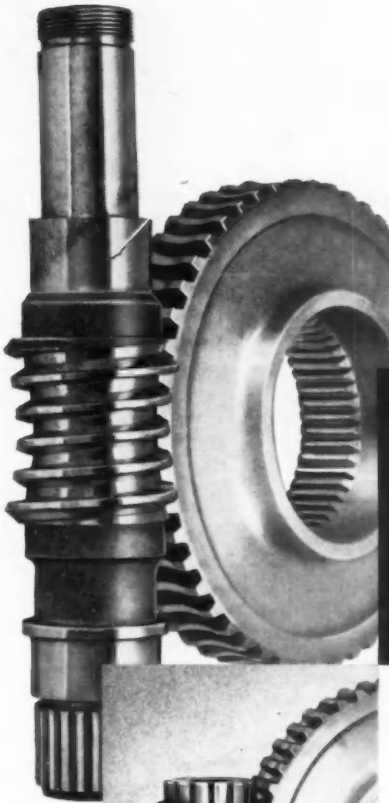
Backlash may be controlled to within .0005 of an inch or less, if necessary, which makes Vard worm and gear sets ideal for instrument and control drives.

CUSTOM DESIGN

At present Vard is equipped to manufacture worm and gear sets in any quantity in a range of center distances from 1 to 8 inches.

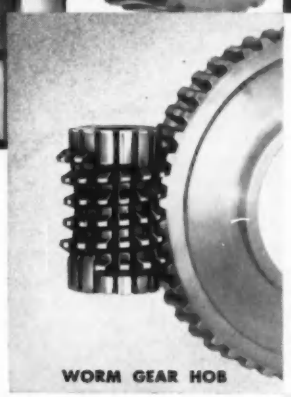
For further information, write for Engineering Data Booklet No. 1002.

Vard, Inc. 2981 East Colorado Street
Pasadena 8, California



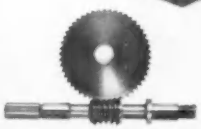


VARD WORM GRINDER



WORM GEAR HOB





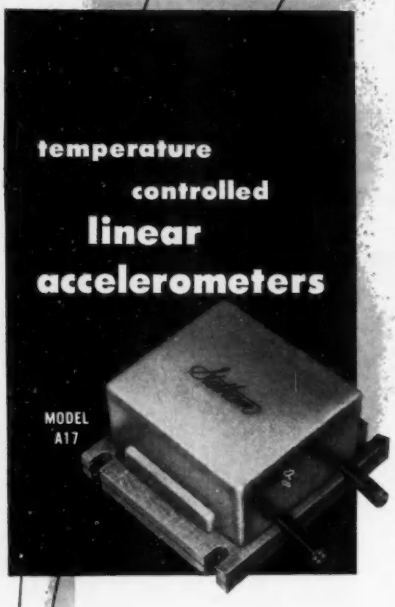
SERVO OR MINIATURE CONTROL COMPONENTS



INDUSTRIAL GEAR BOXES

FIRST in custom gearing

VARD



The usefulness of Statham unbonded resistance strain gage accelerometers has been further extended by special temperature control packaging which ensures that dynamic as well as static characteristics remain constant despite temperature variations such as are encountered in flight applications.

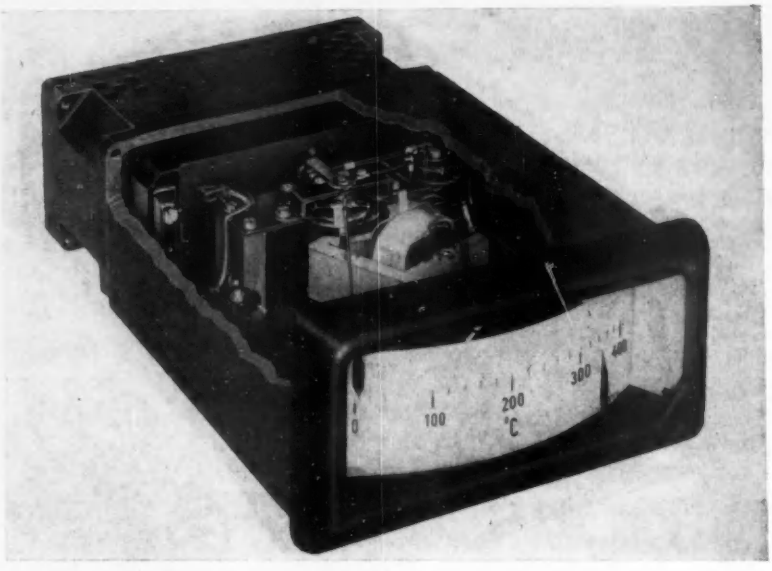
Operation through the ambient temperature range −65° F. to +120° F. is afforded by means of an electrical heater jacket with a peak power input of approximately 20 to 30 watts.

Depicted is the Model A17 accelerometer which is offered in ranges from ±1g to ±15g. Other temperature controlled models cover ranges from ±0.5g to ±15g.

Please request Catalog Bulletin No. AT-1.

Statham
LABORATORIES, INC.
12401 W. Olympic Blvd. • Los Angeles 64, Calif.

NEW PRODUCTS



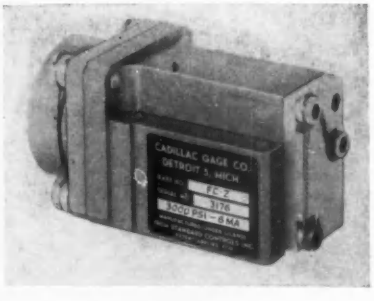
ELECTRICAL PROPORTIONER for pneumattic conversion provides error signal.

This instrument is one of a pair intended for electropneumatic conversion. Actually it is an indicating dc differential amplifier, whose output is the difference between a set point and the input. Internally it consists of a differential transformer transducer that is positioned to the desired setpoint of a control system by the lower pointer on the dial face. Currents generated within the transformer control the output of a vacuum tube. The input from the temperature pickup goes into a meter movement, which is mechanically linked to the other half of the differential transformer. When the meter movement, corresponding to the input, lines up with the set point, the output from the transformer is zero, and consequently the output from the tube is zero. The pneumatic controller is in a separate housing. By means of an electromechanically operated pilot, it delivers air pressure proportional to its input current. Two movements are available for the meter pictured, one for use with thermocouples, the other with resistance thermometers. Throttling range is adjustable through 20 per cent. Called the Swing Coil Regulator, the instrument is made by AEG of Frankfurt on Main, West Germany, and imported by a representative for under $400. *Donald C. Seibert, Box 281, Wilmington, Del.*

Circle No. 16 on reply card

HYDRAULIC FLOW proportioned to milliamps.

Hydraulic flow is kept proportional to an input signal by this two-stage, four-way valve. Signal levels as low as 6 ma produce full valve flow. Supply pressures from 500 to 3,000 psi are handled with peak power delivery of 10 hp to the load. Use in high dynamic servo loops with high force levels is seen as its principle employment when it will withstand temperatures of up to 250 deg F. *Cadillac Gage Co., Detroit 5, Mich.*



Circle No. 17 on reply card



SPECIFICATIONS

INPUT
20 to 35V DC
at approx. 5 m.a.

OUTPUT FREQUENCY
400 or 500 cycles

Type 2007T
+ —.02% from —65° to + 85°C.

Type R2007T
+ —.002% from + 15° to + 85°C.

Type W2007T
+ —.005% from —65° to + 85°C.

OUTPUT VOLTAGE
5 volts, sine wave.

Substantially uniform
from —65° to + 85°C.

LIFE EXPECTANCY
several times that of vacuum tubes

INTERNALLY SHOCK MOUNTED
on Silastic

MAGNETICALLY SHIELDED

HERMETICALLY SEALED

OCTAL BASE

SIZE
4½" x 1½" diameter

WEIGHT
7 ounces

COMPLETE INFORMATION ON REQUEST
PLEASE SPECIFY TYPE 2007T

Precision

FREQUENCY STANDARDS

These units, which are the result of several years of development and testing, offer a new standard of simplicity and reliability. Particularly noteworthy is the uniformity of output signal voltage with temperature change. Small size and light weight make them ideal for airborne and portable use.

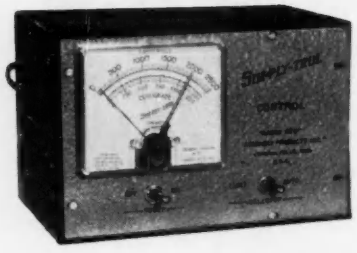
For applications where only higher B voltages are available, a simple voltage reducing circuit may be used.

American Time Products, Inc.

580 Fifth Avenue ***New York 36, N. Y.***

MANUFACTURING UNDER PATENTS OF WESTERN ELECTRIC COMPANY

SIMPLYTROL AUTOMATIC PYROMETER



Cat. No. 4531 0 2500° F.
Price $132.00

Thermocouple type Automatic Pyrometer for controlling temperature in furnaces, ovens, and processes. The Simplytrol is economical and reliable with few moving parts. There are no vacuum tubes. The regular load relay is S.P.D.T. 5 Amps. Optional heavy duty relays to 40 Amps.

10 temperature ranges cover from −75° to 3000° F. Several special ranges to −400° F. "On & Off" control for holding the desired temperature works on gas, oil or electric heat. Indicating meter-relay is medium high resistance and has bimetal cold junction compensation. For use with all standard thermocouples. Accuracy 2%.

"Auto-Limit" switch changes Simplytrol from automatic controller to limit pyrometer for safety shut down or warning. Cabinet: 6½x6½x9½ inches. Also flush panel mount models. Send for new Bulletin G-7 for more data. Assembly Products, Inc., Chesterland 22, Ohio.

Booth 311, I.R.E. Show, March 21-24

NORTHAM

HIGH SENSITIVITY, LOW RANGE

PRESSURE TRANSDUCER

Diameter: 2¼"



Weight: 12 oz.

An extremely sensitive variable inductance instrument for measurement of steady and transient pressure in full scale ranges as low as ± 4 inches of water. Permissible pressure overload in either direction up to maximum line pressure, 100 psi, for difficult flow-metering applications. A light diaphragm sensing element free from external mechanical linkage results in high natural frequency for dynamic measurements.

MODEL DP-7 SPECIFICATIONS:

Pressure Ranges:....± 0.15 to ± 15 psid
Maximum Line Pressure:.....100 psi
Accuracy:.....± 1% full scale
Excitation Frequency: From 60 to 20,000 cps
Natural Frequency: From 250 cps for 0.15 psi range to 2500 cps for 15 psi range

WRITE FOR BULLETIN NO. CE-7

Northam Engineering Facilities Are Available To Assist You With Any Application Problems.

NORTHAM PRODUCTS INCLUDE . . .

Transducers for pressure, acceleration and displacement measurement and auxiliary electronic equipment for complete systems.

NORTH AMERICAN INSTRUMENTS, INC.

2420 North Lake Avenue • Altadena, Calif.

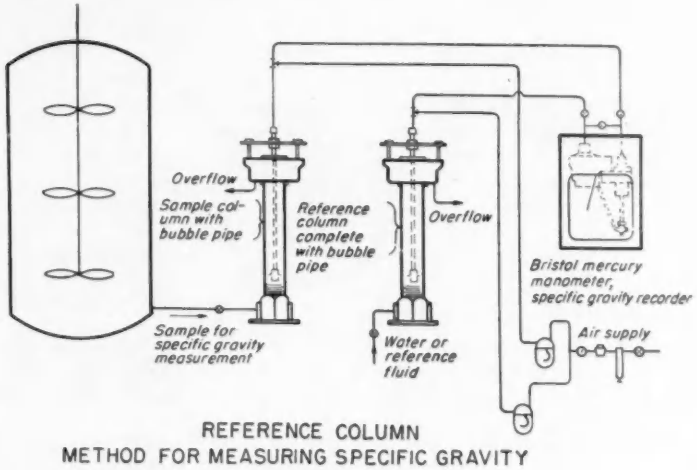
NEW PRODUCTS

CONVERTS MILLIVOLTS into pneumatic pounds.

Essentially a voltage-to-pressure converter, this Swartwout Type T3C Thermocouple-Air Converter uses a dc millivolt input signal to regulate an air loading pressure of 3 to 15 psig. Its selling point is the possibility of combining new electronic components into systems now largely pneumatic. The instrument has no batteries, slide wires, or motors. The input, from a thermocouple, is amplified and used to electromagnetically balance against a pneumatic pilot. Thermocouple temperature range is minus 50 to plus 3,000 deg F. The electrical span is 2 to 50 milliv, error 1 per cent, reproducibility 99.75 per cent of span, and ultimate sensitivity finer than 0.01 per cent of span. *The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.*



Circle No. 18 on reply card



REFERENCE COLUMN
METHOD FOR MEASURING SPECIFIC GRAVITY

SPECIFIC GRAVITY by bubbling against water.

The specific gravity of fluids is measured and recorded by a new Bristol line of specific-gravity meters by noting the difference in pressure required to blow bubbles through a column of the measured fluid, and a standard column of water. For closed systems, a radiation density meter is offered. *The Bristol Company, Waterbury 20, Conn.*

Circle No. 19 on reply card

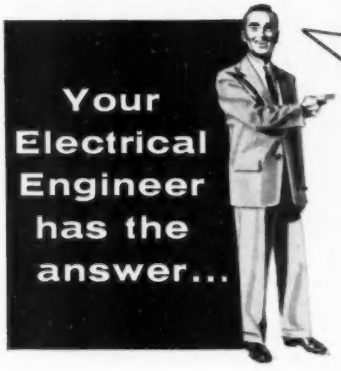
FEEDBACK FACT

Posed: A wireless hearing-aid for the vain hard-of-hearing.

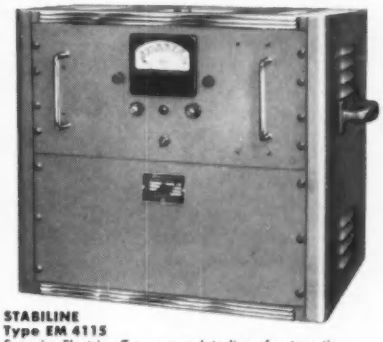
Solved: They can't be too vain. Otarion has come up with a hearing aid that's assembled inside a standard eyeglass frame—so they have to wear glasses.

V.V.T.*

the "Phantom Saboteur" of Automation can cause 101 production troubles... rejects . . . without your knowing it!



* "Varying Voltage Trouble plays hob with timers, solenoids, and electronic gear in production and inspection departments. A Stabiline Automatic Voltage Regulator prevents this 'sabotage'."



STABILINE
Type EM 4115
Superior Electric offers a complete line of automatic voltage regulators. Send for Bulletin S351.

• Automatic machines and processes . . . inspection department equipment can go "haywire" every time your voltage varies — even within so-called "allowable limits". Given the opportunity your plant Electrical Engineer can spot V.V.T. and help you cure many production headaches you now consider to be "routine trouble" that you have to live with. When he recommends a Stabiline automatic voltage regulator you can be sure *these* troubles are under control.



See Superior Electric's Mobile Display when it visits your area.

THE SUPERIOR ELECTRIC COMPANY

BRISTOL, CONNECTICUT

Manufacturers of: POWERSTAT Variable Transformers • STABILINE Automatic Voltage Regulators • VOLTBOX A-C Power Supplies LUXTROL Light Control Equipment • VARICELL D-C Power Supplies Superior 5-WAY Binding Posts

THE SUPERIOR ELECTRIC COMPANY, 603 Reynolds Ave., Bristol, Conn.

Please send me a copy of your STABILINE Bulletin S351.

Name.....

Company Name.....

Company Address.....

City.....Zone.....State.....

TRANSISTOR &
DIGITAL COMPUTER
TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

ENGINEERS
&
PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

FIELDS INCLUDE

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
LOGICAL DESIGN
PROGRAMMING
VERY HIGH POWER MODULATORS AND TRANSMITTERS
INPUT AND OUTPUT DEVICES
SPECIAL DISPLAYS
MICROWAVE CIRCUITS

Scientific and Engineering Staff

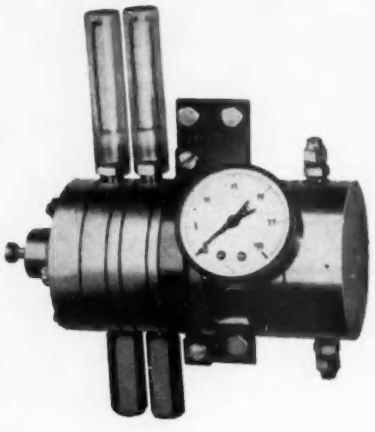
HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

NEW PRODUCTS

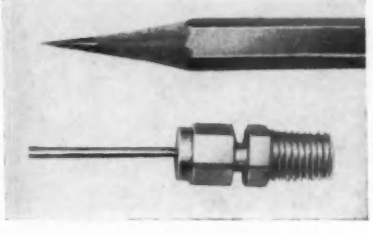
GETS THE AIR to instruments proportional to fluid pressure.



Essentially a simple computing component is this low-pressure, low-cost force-balance pneumatic transmitter. Its pneumatic output may be a direct or inverse function of a single fluid pressure, or the difference or sum or average of two. The manufacturer claims it has no delicate or complicated parts, no wear or friction, and is unaffected by air supply changes. Although protected from overload, its maximum pressure measurement is 35 psi. *Builders-Providence, Inc., Providence, R. I.*

Circle No. 20 on reply card

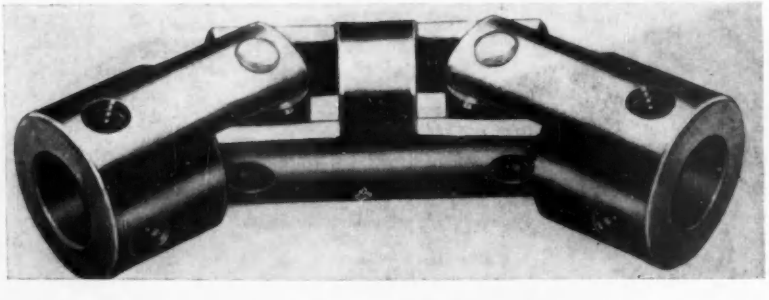
CAPILLARY TUBE fittings now in stock.



Tube fittings for 1/8 in. capillary tubing are available from Swagelok. Operating on the same principle as the larger fittings, the new size requires no special tools or flaring to do its job. Many different metals are used for the new fitting, now in stock. *Crawford Fitting Company, 884 East 140th St., Cleveland 10, Ohio.*

Circle No. 21 on reply card

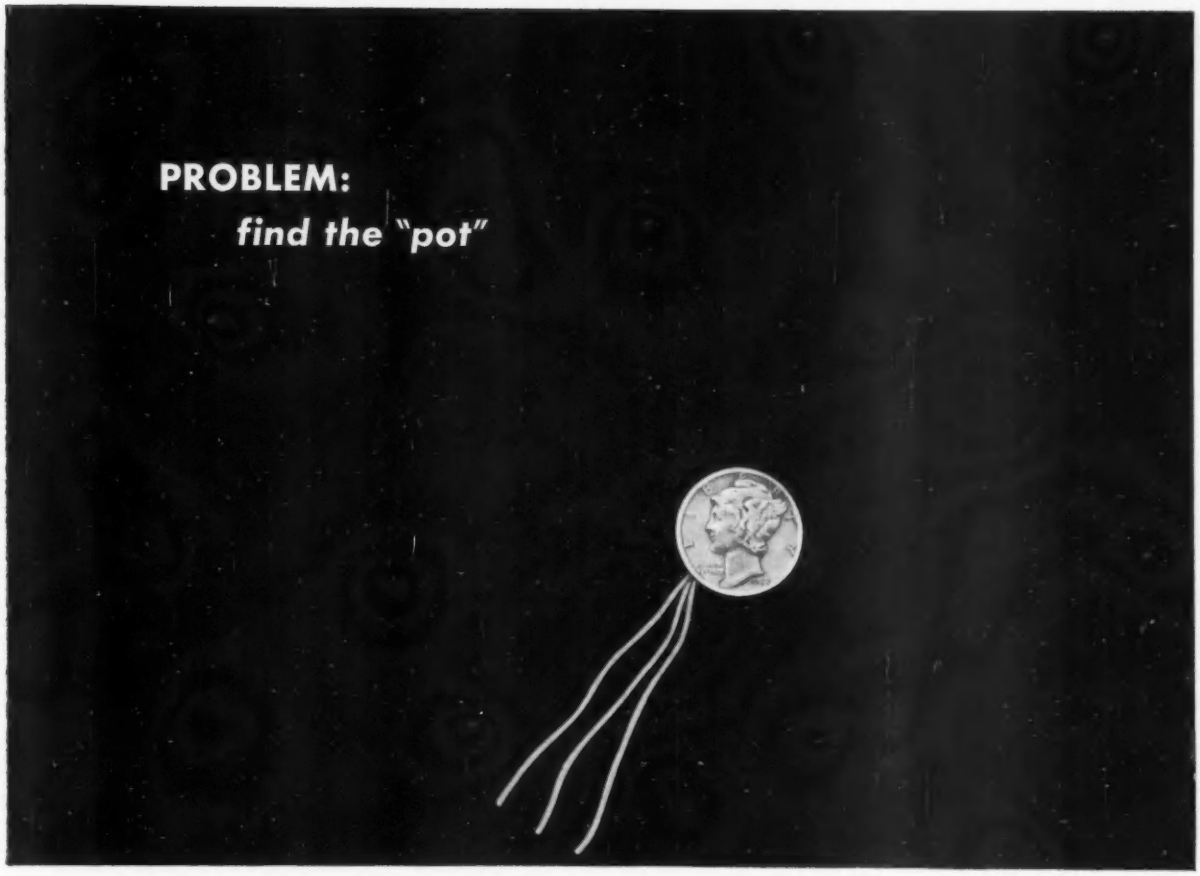
PLAYFUL JOINTS allow for more misalignment, and rotate at 90 degrees.



Lateral as well as angular displacement is provided for in some new inexpensive universal joints. The joint shown will operate with included angles of 90 deg and more, with practically all cosine error balanced out. Made in a range of sizes shown in the companies catalog 5599, the units offer greater adaptability at a lower price than standard joints, the company claims. *Kupfrian Manufacturing Corp., 154 Prospect Avenue, Binghamton, N. Y.*

Circle No. 22 on reply card

PROBLEM:
find the "pot"



This is the "Tail" of "TINY TRIM"

The newest, smallest, most ruggedly-accurate wire-wound potentiometer on the market!

If you are having trouble finding the right "pot", a "pot" that will fit into the tiniest space, weigh less than an overstuffed feather, and still provide unexcelled accuracy and resolution characteristics, you will want to know about "TINY TRIM"—the sub-miniature, wire-wound potentiometer produced by DAYSTROM POTENTIOMETER . . .

So **SMALL** and **COMPACT** it can easily be covered by a dime (3/16 inch thick). One half as large as its nearest competitor.

So **RUGGEDLY ACCURATE** it can be used for the most exacting applications.

- ***High Power Rating***
- ***Extremely Fine Resolution***
- ***80 to 1 Adjustment Ratio***
- ***Designed to stack (96 units in a space 3 inches by 3 inches by 1/2 inch)***

"TINY TRIM" is just one of the many production or custom-made potentiometers available from DAYSTROM POTENTIOMETER.

DAYSTROM POTENTIOMETER
DIVISION OF DAYSTROM PACIFIC CORP.

Openings available for qualified engineers.

1509 COLORADO AVENUE • DEPT. 13 • SANTA MONICA, CALIFORNIA

See the

SERVO

all-star line-up

at the

IRE SHOW

BOOTHS

203 AND 300,

PRODUCTION ROAD



★ **Radio Instrument Line**

Navigation Direction Finding
Radar Facsimile Recorder
Measurement Instruments
Communication Receivers
High Voltage Power Supplies

★ **Servolab Instrument Line**

Servoscope*
Servoboard*
Servo Amplifiers
Servolab Building Blocks

★ **Infrared Measurements Line**

Bolometer and Preamplifier
Recorder Amplifier
Pyrometers

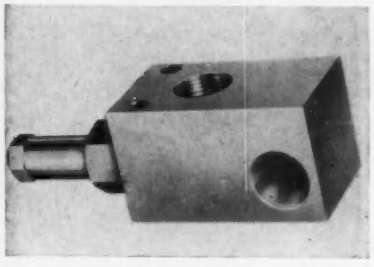
* REG. TRADE MARK

SERVO

SC-128

SERVO CORPORATION OF AMERICA

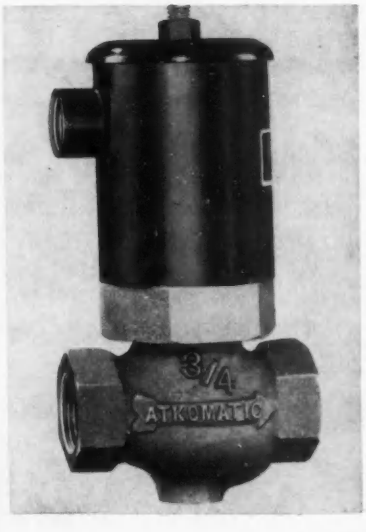
NEW HYDE PARK, NEW YORK



PRESSURE CONTROL via relief valve.

Used in hydraulic clamping and feed circuits, this guided-piston-type valve is recommended where pressure is maintained through continuous flow through relief valves. Its operation consists of a piston being pushed against a spring at the appropriate pressure the outlet port it otherwise covers. Both piston and sleeve are hardened and honed to a precise fit. The fluid in the spring cavity dampens the valve and prevents chatter. The pressure range is 10 to 600 psi, adjustable through a hand knob. ⅜, ½, and ¾ in. sizes are made. *Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio.*

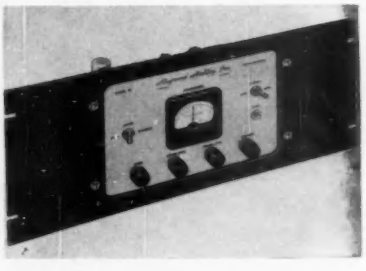
Circle No. 23 on reply card



SOLENOID VALVE handles many media.

The special feature of this solenoid valve is complete opening even at zero pressure. At higher pressure, the solenoid operates a pilot valve orifice, releaving pressure on top of a piston. Line pressure then lifts the piston, revealing the port area. Guarded against water hammer, the valve operates with air, freon, water, oil, low pressure steam, or other media not harmful to bronze or 316 or 416 stainless steel. Pressure range: 0 to 150 psi. Temperature: to 250 deg F. *Atkomatic Valve Co., Dept. 1, 545 Abbott Street, Indianapolis, Ind.*

Circle No. 24 on reply card



AMPLIFIER for pneumatic or hydraulic servovalves.

Model 32 servoamplifier generates a 4 kc signal to excite variable-reluctance or E-type differential transformer pick-offs, and has provision for plug-in compensating networks to alter servo system for variable dynamic response, and a 100-to-400 cps dither frequency on the output to reduce static friction on the controlled valve. The output current level is adjustable from 8 to 20 ma. The dc output is at a high impedance level to minimize inductance lags from the coils in servovalve electro-mechanical actuators. *Raymond Atchley, Inc., 12012 W. Pico Blvd., Los Angeles 64, Calif.*

Circle No. 25 on reply card

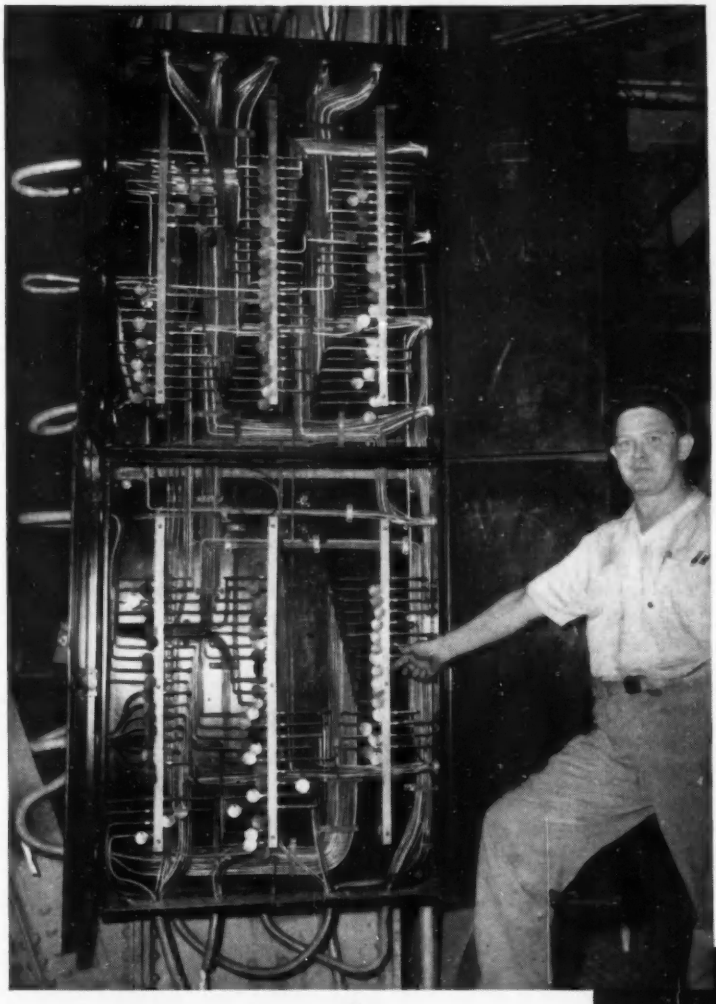
FEEDBACK FANCY

Needed: Means for extracting oven goodies at their peak of eye appeal.

Suggested: A simple colorimeter-scanner in oven-dial on the wall over the TV set. When the needle points to the desired golden brown, a quick dash to the kitchen can be made.

FOR INSTRUMENTATION AND CONTROL

Cabled Tube



Control Junction Box at Power Station of Long Island Lighting Company, showing use of Crescent Armored Multitube. Note that relatively sharp bends can be made without damage to the cabled copper tube.

Some time ago Revere ran an advertisement featuring Crescent Armored Multitube for use in pneumatic and hydraulic instrumentation and control systems. The advertisement created so much interest that we thought you might like to see a photograph of an actual installation. The Control Board Junction Box shown here has 22 runs of Multitube coming into this box comprising 224 Revere Copper Tubes of 1/4″ O.D. The picture was taken in the Glenwood Landing, N.Y. Power Station of the Long Island Lighting Company. The tubes go to instruments that report information on temperature, main and reheat steam pressure, boiler feed and condensate pump pressure, fuel oil and gas pressure, liquid levels, tide level and for the control of fuel feed, draft dampers, boiler drum water level and various control valves.

This is a relatively new use for Revere Copper Tube, but it is an important one in these days when new ways are being found to obtain process information more quickly and accurately, or to achieve automatic control. Crescent Armored Multitube is made by Crescent Insulated Wire & Cable Co., Inc., Trenton 5, N.J., in lengths up to 1,000 feet. It consists of a group of long tubes twisted together in cable form, protected by a flexible interlocked galvanized steel armor, or by plastic, or both. As many as 19 tubes, 1/4″ O.D., can be cabled, with one tube in each layer color-coded. Larger tubes can also be cabled, including 5/16″, 3/8″ and 1/2″. This construction affords protection during shipment, installation and use, and speeds up installation greatly. For further information, write Crescent, and for tube in copper and aluminum, see the nearest Revere Sales Office.

REVERE

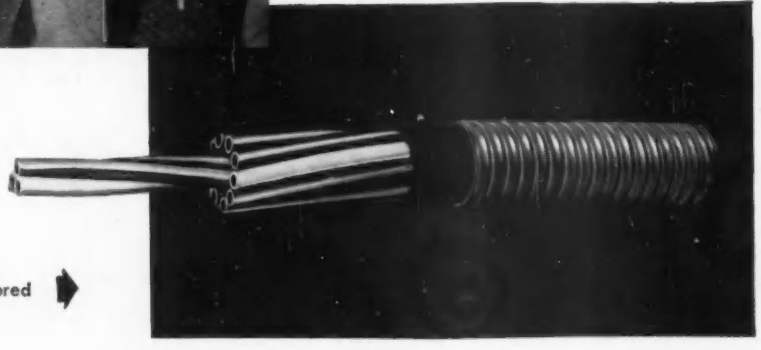
COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

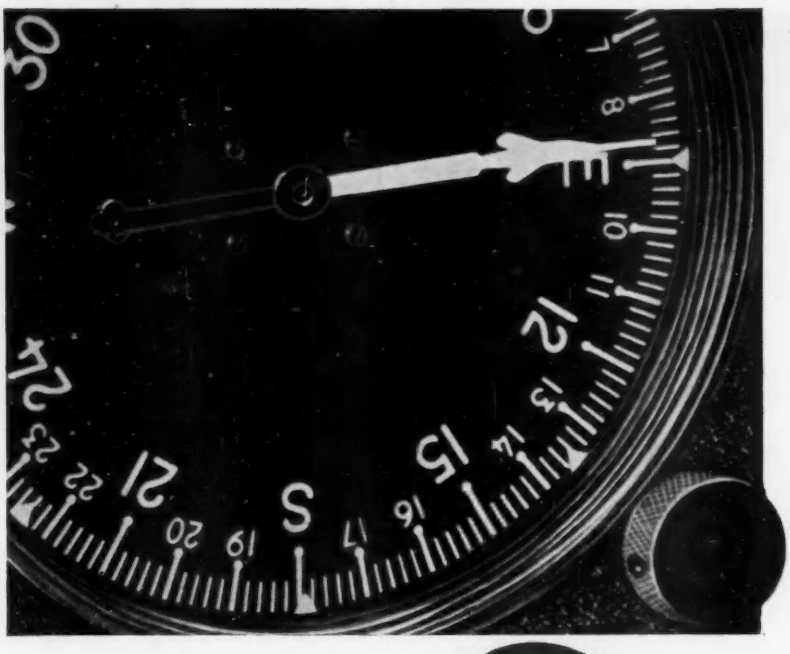
230 Park Avenue, New York 17, N. Y.

• • •

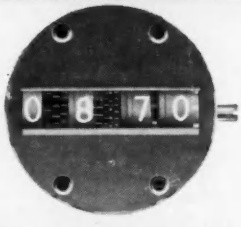
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.



Construction of Crescent Armored Multitube.



Both the Counter and the Dial Indicator are shown full size.



WHICH IS READ WITH GREATER ACCURACY?

The Kearfott Counter shown can be read with the same ease and accuracy as a dial indicator 143 inches in diameter.

Ball Bearings and precision hardened steel parts used in Kearfott Counters permit their high speed rotation for long periods of time. Kearfott Counters are capable of being driven at 1800 RPM. Precision parts also contribute to precise positioning and precise reading.

STANDARD KEARFOTT TYPES

ANGLE COUNTERS: Odometer indication of shaft position, fully reversible operation returning to 0° at end of count. Either 0°-359.9° in 1/10 or 0°-359° in ½° increments as desired. Maximum speed 1800 RPM.

DECIMAL COUNTERS: High speed decimal count from 0-9999 and return to 0 in ½ increments. Maximum speed 1800 RPM. One revolution of shaft equals 10 units.

LONGITUDE COUNTERS: For east-west longitude indication in degrees and minutes in ½ minute increments. Mask transfers hemispheric indication at 0° and 179°59'. Maximum speed 1800 RPM.

LATITUDE COUNTERS: Indicates N 89°59' to S 89°59'. For same direction of input the mask transfers hemispheric indication and reverses reading at 00 degrees 00 minutes. Maximum speed 1800 RPM.

Variations of these Standard Types are available for special purposes.

KEARFOTT DISPLAY AT THE NATIONAL I.R.E. SHOW, KINGSBRIDGE ARMORY, NEW YORK, BOOTH 152.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Send for bulletin giving data of Counters and other components of interest to you.

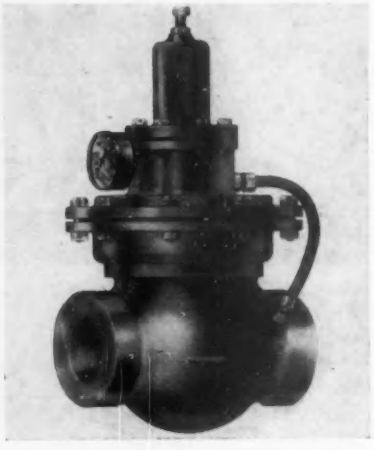
Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

NEW PRODUCTS



CLOSE REGULATION of low-pressure gas and air.

Claims for this low-pressure controller are that it is more sensitive to fluctuations than weight-loaded regulators and has a much wider range of adjustment than units relying on direct spring loading. The Type 73-22 Back Pressure Regulator with Integral Controller works equally well with gas or air, and features a high-tensile cast iron valve body, pilot operating mechanism machined from stainless steel and aluminum, Buna-N valve diaphragm with no center punching, Buna-N soft seat insert, spring-loaded Teflon packing, and valve seat machined into the valve body. Available size are 2 in. screwed globe, 3 and 4 in. flanged globe. The control range is from 5 to 125 lb., up to 165 deg F. *Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Mo.*

Circle No. 26 on reply card



PULSE-CODE telemetering system for liquid levels.

Using elements and circuits roughly similar to those mentioned in the Ger-

man telemetering system described in this issue's "Ideas at Work" section, the Pulse Code system differs in that it provides readout on the instrument shown, and a dial-type tank selector. Accurate to $\frac{1}{8}$ in. through a 60-ft range, this system has circuits with check signals for errors and rejecting code groups that omit the required number of dots and dashes. Readout time is 5 sec. *The Vapor Recovery Systems Co., 2820 N. Alameda St., Compton, Calif.*

Circle No. 27 on reply card

LOW COST pneumatic controller is available.

A pneumatic controller is now available in the low price range. Providing sharp on-off action, or proportional throttling action from $\frac{1}{4}$ per cent up to 25 per cent of scale, model 41A accommodates standard Foxboro measurement elements. *The Foxboro Co., Foxboro, Mass.*

Circle No. 28 on reply card

COOLER HELPS pressure pickups in hot spots.

When pressures of fluids or gases in the 4,000 deg F range are to be measured, a new cooler may be valuable. The tiny adapter simply screws into the hole intended for the pickup, which then screws into the adaptor. Water flows through the adaptor to keep the temperature down. Pickups made by the manufacturer range from 0-10 psi to 0-3,000 psi, and will respond to changes up to 3,000 cps. *Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.*

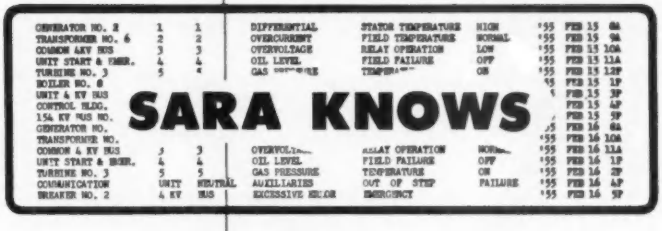
Circle No. 29 on reply card

FEEDBACK FACT

Posed: How to extend breakfast cereal box commercials to the non-reading tot.

Solved: Small fry now rip off a plastic record from Wheaties and are fed-back health-building truisms from their nearby toy phonographs.





(AND CAN TELL YOU INSTANTLY, AUTOMATICALLY... **SEQUENTIALLY!**)



TALLER & COOPER'S SARA

——"the desk with a brain"—is Taller & Cooper's Sequential Automatic Data Recorder and Annunciator that keeps an exact, automatic log of widespread, complex plant and industrial operations.

● Gives audible and visible warning of every failure or irregularity ● Prints a sequential log of every change in operating conditions ● Immediately prints the exact sequence even when change of conditions occur within milliseconds of one another ● Watches as many as 500 separate operations continuously, automatically

Not only a brain, but a *memory*, too! SARA sees all—records all.

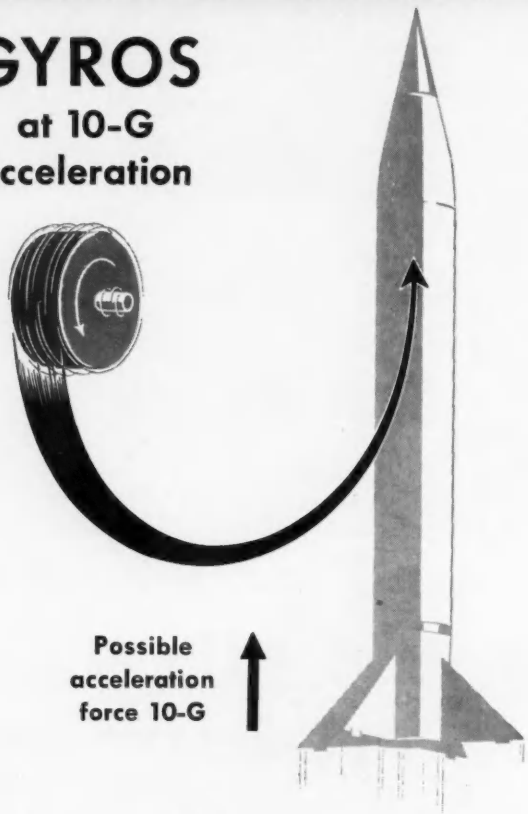
Write today for New Technical Bulletin No. 101 on SARA.

CONTROL EQUIPMENT & SYSTEMS.
DIGITAL COMPUTERS.
TOLL COLLECTION SYSTEMS.
WIND TUNNEL INSTRUMENTATION.
SPECIAL PURPOSE PRINTERS & INSTRUMENTATION.
CHEMICAL ANALYZERS & CONTROL EQUIPMENT.

TALLER & COOPER, INC.
ENGINEERS • MANUFACTURERS
75 FRONT ST. • BROOKLYN 1, N. Y.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

GYROS
at 10-G acceleration



The gyroscope in a missile guidance system must be able to withstand acceleration forces up to 10 G's in any direction. This gyroscope, designed and developed by the Guided Missile Development Division of the U. S. Army and the Ford Instrument Company, will function under this acceleration. Tests have shown these gyros to be accurate to 1/50° per hour drift, or better.

For forty years, Ford has been building gyroscopes, at first for navigation devices, later for stabilization in many fire control problems. Ford designed and manufactured gyros have been in the stabilization systems of heavy battleship guns, in missiles and torpedoes and in delicate airborne instruments. Stable platforms and guidance systems have been outstanding achievements of Ford Instrument Company engineers.

Since 1915, the engineers at Ford Instrument Company have specialized in such equipment as computers, controls, and servo-mechanisms in hydraulics, electronics, mechanics and magnetics for the Armed Forces and for industry. If you have problems in any of these fields, it will pay you to discuss them with Ford engineers.

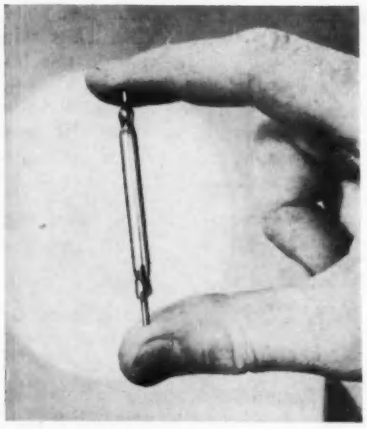
49

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

NEW PRODUCTS

ELECTRO-MECHANICAL MECHANISMS



SWITCH MAKES RAPIDLY by means of magnetic force.

A nearby permanent magnet or electromagnet operates the miniscule contacts of this dry-reed switch in superfast time. The contact surfaces are Rhodium electroplated, and the whole thing sealed in a nitrogen atmosphere. A bulletin is available with details. *Revere Corp. of America, Wallingford, Conn.*

Characteristics

Operating time.....1 millisec
Operating rate.....400 cps max
Contact resistance...0.05 ohms max
Rating.....0.5 amp inductive at 115 v, 60 cps

Circle No. 30 on reply card



RESOLVER'S RESOLUTION is far better than a New Year's.

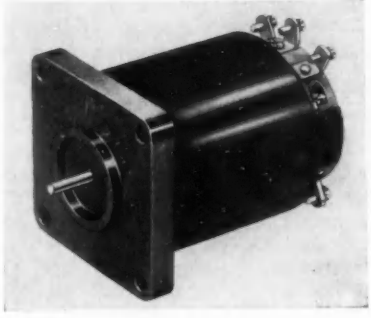
Rated for continuous duty, this tiny precision resolver is available with various shafts. High impedance figures are listed below. *American Electronic*

Mfg., Inc., 9503 W. Jefferson Blvd., Culver City, Calif.

Characteristics

Size.....1.065 in. OD, 1.85 in. long
Input voltage....at 400 cps..0 to 100
Max. null voltage.....1 milliv per v input
Null spacing....plus or minus 3 min
Maximum phase shift....6.5 plus or minus 1 deg
Q 4.6
Starting friction .....0.05 in.-oz

Circle No. 31 on reply card



RESOLVER RESPONDS rapidly to steps.

Fast response is the feature of this resolver. When checking null voltage output, the voltage decays to 2 milliv within 175 microsec after switchover with a 13v, 1,000-cycle square wave applied to the primary. Nominal input is 26v, 400 cycles with a transformation ratio of .29, plus or minus 5 per cent. *John Oster Mfg. Co., Avionic Division, Racine, Wis.*

Circle No. 32 on reply card

DC SUPPLY for flying strain gauges is battery-sized.

Intended to fit the space required by the battery it replaced, a new magnetic-amplifier-controlled dc power supply provides precisely stable voltages in the 28-to-32 range for use with strain gages in aircraft. Input fluctuations between 105 to 125 v, and 380 to 420 cps, ac, do not disturb its output beyond 0.2 per cent. Recovery time is better than 0.2 sec. Potting of all parts helps keep characteristics stable up to 70,000 ft. *Engineered Magnetics, 11812 Teale St., Culver City, Calif.*

Circle No. 33 on reply card

PULSE ACCOUNTING

There are entirely too many pulses batting around lately that we don't get paid for. A good many of them go by so fast we can't find them, let alone reform and charge for them, but there are still a goodish number of slow pokes which neatly sidestep our keying relays.[1] We are now gunning for these.

To be doubly sure of catching them gainfully, we propose to collect them in tin boxes with the quantity marked right on top.



The Sigma Cyclonome Pulse Counter consists of a special 6 figure Veeder-Root register driven by a completely novel stepping motor* with but one moving part which rotates in ball bearings and drives the counter through a Nylon worm. Starting and stopping is accomplished magnetically *each* half cycle. Counting rate is nearly 8000 per minute (0 to 130 pulses per second) at an accuracy of ±1/2 count, and, depending on the user's choice, the device will accept either DC pulses down to 3 milliseconds wide (50% on-time minimum at 130 pulses per second) or AC cycles with a minimum half-cycle of 3 milliseconds.

Average power required varies with frequency, from 1/2 watt (AC input) at 20 cps to 12 watts (DC input) at 130 pulses per second.

This device will advantageously replace the slow decade and mechanical registers in computers and electronic counters, as it has a life of at least 500,000,000 counts, and is adaptable to production and process counting. By special arrangement with the Fisher-Pierce Company, specialists in photoelectric devices, we can provide photoelectric sensing equipment to drive the Sigma Cyclonome Counter.



ELECTRICALLY DRIVEN COUNTER
8,000 COUNTS PER MINUTE

The Sigma Cyclonome motor (separately available) has attractive features as a stepping motor. There are no reciprocating parts to wear or clatter; torque output is about 1.3 inch-ounces and stepping speed is 260 half-steps (20 per revolution) per second. Size, about 1-3/8" x 1-7/8" x 2-1/2". Another model with twice the torque (same speed) is 1-7/8" x 1-7/8" x 2-1/2". Caution: the inertia of driven devices must be reckoned with and we will be glad to work out the details on samples thereof.

Price and application information are available.

[1] A new complete catalog of Sigma Sensitive Relays is available if specifically requested.

*Patent Applied For.

SIGMA

SIGMA INSTRUMENTS, INC.
69 Pearl Street, So. Braintree, Boston 85, Mass.



A new, large size, flat bed, versatile 2-axis recorder...

AUTOGRAF
trademark
MODEL 2

The versatility and labor-saving convenience of the original portable Autograf have now been built into an instrument which handles standard 11" x 16½" graph papers. Model 2 has the same scales and ranges as Model 1 (0-5 millivolts to 0-100 volts each axis); same speed (full scale X and Y in one second); same input impedance (200,000 ohms per volt). In addition, depressed zero available each axis, larger recording area (twice as big), flat bed, easy-reading design.



THE AUTOGRAF MODEL 1
general purpose 8½" x 11" X-Y recorder—is doing duty in hundreds of laboratory applications: chemical, electrical, electronic, wind tunnel, computer...And on production lines: measuring motors, filters, tubes, transistors, airfoils, amplifiers, rectifiers, magnetic circuits and materials, nuclear devices, etc....



Curves are available for observation and labeling while they are being drawn.



BOTH AUTOGRAF MODELS ARE OUTSTANDING FOR THEIR VERSATILITY

AUTOGRAF CURVE FOLLOWER
plots or reads out Y vs. X. Either Model 1 or Model 2 can be furnished as a recorder/curve follower.

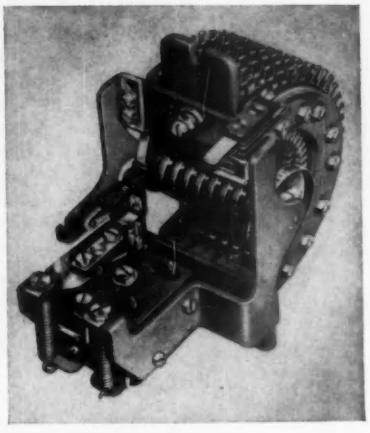
AUTOGRAF POINT PLOTTER
Models 1 and 2 may be fitted for point plotting from keyboard or other digital sources.

NEW MODEL 20 SERIES DC VOLTMETER
A new high accuracy, easy-to-read, multi-range servo-voltmeter with fast response. Scales 0-3 millivolts to 0-300 volts. Zero left or zero center. Designed for indication, control, or analog to digital conversion.

Bulletins describing these instruments are available, and we will be glad to send you the ones you want. Write...

F. L. MOSELEY CO., 407 NORTH FAIR OAKS AVENUE, PASADENA 3, CALIFORNIA

NEW PRODUCTS



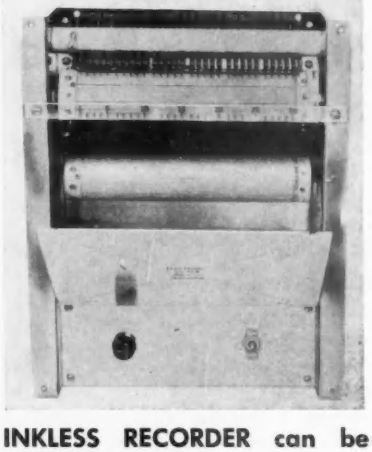
FAST STEPPING switch has real longevity.

Made by the General Electric Co. of England, this heavy duty stepping switch features high stepping rate and long life. Bank contacts, wipers, collector rings, and brushes are made of nickel-silver. *IMTRA Corp., 58 Charles St., Cambridge 41, Mass.*

Characteristics

Life.....100 million steps
Speed.....up to 68 steps per sec
Contacts....5 or 8 double-ended wipers or 10 single-ended with 25 contact banks
Coils.....22, 40, 50, or 60 vdc or special

Circle No. 34 on reply card



INKLESS RECORDER can be panel mounted.

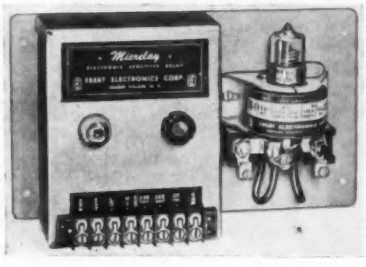
Non-fading electro-sensitive paper is used on this 30-channel inkless recorder, of portable-typewriter dimensions.

Events are indicated as either "on" or "off" by the appearance or absence of the appropriate marking line. A

range of motor speeds drive the 7-in.-wide edge-perforated paper. A 63-ft-long roll is accommodated in the instrument. Electric clutch motor drive allows for starting and stopping at precise times. Marking current is either ac or dc, the required potential varying with chart speed.

The maker has a leaflet illustrating this and a circular inkless recorder that they make also. *Larson Instrument Co., 24 Orchard St., Tarrytown, N. Y.*

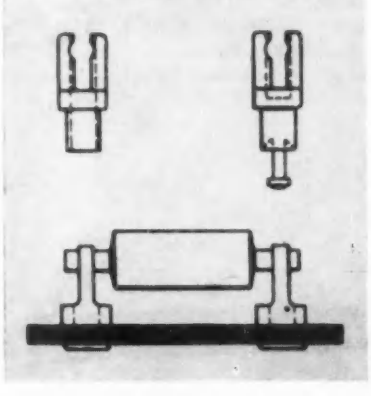
Circle No. 35 on reply card



RUGGED RELAY converts 3 microamps to 10 hp.

Lost cost and high reliability are built into an industrial relay by Ebert, which handles current loads up to 60 amp or 3 hp from very weak current systems. Closure time is 35 millisec from current sources as low as 3 microamp from a 10 megohm impedance source, at 9 vac or 12.5 vac. *Ebert Electronics Corp., 212-26 P Jamaica Avenue, Queens Village 28, N. Y.*

Circle No. 36 on reply card



CLIPS DIODES for many purposes.

Clips for crystal diodes with shafts between .075 to .080 in. diam are available from Lerco. Silver-plated brass ensures good contact. Three mod-



vernistat...*The Revolutionary New Precision Variable-Ratio Transformer*

Analog Computers? Servos? Control Systems? Vernistat is a completely different type of voltage divider combining **low output impedance with an inherently high resolution and linearity** not ordinarily attainable by precision potentiometers.

The Vernistat consists of a tapped auto-transformer which provides the basic division of voltage into several discrete levels. These levels are selected and further sub-divided by a continuous interpolating potentiometer that moves between 30 transformer taps.

Because of its unique operating principles, electrical rotation is held to close tolerances eliminating the need for trim resistors. In many applications there is also no need for impedance matching amplifiers.

Specifications of the standard model Vernistat are shown below. Other versions are under development to meet specific end uses.

What are your requirements for this unique precision voltage divider? Fill in the coupon now.

See it at Booth #20 (Palace)

vernistat division PERKIN-ELMER CORPORATION
NORWALK, CONNECTICUT

SPECIFICATIONS

Linearity Tolerance	better than ±.05%
Resolution	better than .01%
Output Impedance	130 ohms (max.)
Max. Output Current	50 ma
Frequency	50-3000 cps

Other models including a miniaturized 400 cps version will be available in the near future.

vernistat division PERKIN-ELMER CORPORATION
815 Main Avenue, Norwalk, Connecticut

Send me more information on the Vernistat.
The application I have in mind is as follows:.....

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

Here's the versatile, regulated DC source you've been looking for - - -

NOBATRON*-Ranger



turning this knob gives you . . .

100-300DC at 1-10 amps (model SR2)
5-135VDC at 1-10 amps (model SR100)
5-30VDC at 3-30 amps (model SR30)
with ±0.25% regulation accuracy!

The Sorensen Nobatron-Ranger is essentially an adaptation of the proved Nobatron circuit**, with the added feature of continuously adjustable output voltage over a wide range. This makes the RANGER an exceptionally good investment for the many laboratories and test installations where a multi-purpose DC source can be used to advantage.

ELECTRICAL CHARACTERISTICS

Input voltage range	95-130VAC, 1Ø, 50-60~ for models SR30 and SR100 190-260VAC, 1Ø, 50-60~ for model SR2
Output voltage and load range	5-30VDC at 3-30 amps in model SR30 5-135VDC at 1-10 amps in model SR100 100-300VDC at 1-10 amps in model SR2
Regulation accuracy	±0.25% at any output voltage setting with an input between 105 and 125VAC. The accuracy will be slightly less at the extreme value of the input.
Ripple	1% RMS max. of output setting

All RANGERS are 22" wide by 17¼" deep by 47¼" high. They are self contained in handsome cabinets, equipped with casters for easy mobility. Meters are furnished as standard equipment, and there is adequate protection against overload, overvoltage, and tube filament failure.

Write for further information, and for your free copy of the new Sorensen general catalog, to Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. In Europe, please correspond directly with Sorensen A.G., Gartenstrasse 26, Zurich 2, Switzerland.

SORENSEN
375 FAIRFIELD AVENUE, STAMFORD, CONNECTICUT

*Reg. U.S. Pat. Off.
**Model SR2 uses a circuit device patented by Wm. J. Brown.

NEW PRODUCTS

els are available, one of which is for dip soldering. They are sold from stock or mounted per specification. *Lerco Division of Lynn-Deatrick, Inc., 501 S. Varney, Burbank, Calif.*

Circle No. 37 on reply card

ANNUNCIATOR catches both eye and ear.

An off-normal indicating system now available combines sounds, flashing lights, and printed information to get its message through. Enclosed in a miniature case, the high-low annunciator works like this. Each sensed station of a system causes a light to be kept on behind a "normal" panel, illuminating a card that indicates the origin of the signal. As the signal rises above or drops below the normal set point, a card immediately above or below the normal card is illuminated by a flashing light and an audible alarm goes off. The operator must press an acknowledgement button for the sound to stop, but the light will continue to flash behind the off-normal card until the signal returns to its set limits. *Panalalarm Division of Panellit, Inc., 7461 Hamlin Avenue, Skokie, Ill.*

Circle No. 38 on reply card

BIG BUTTON starts tools.

Intended for use on such tools as punch presses is a new large-sized Micro-Switch, named 1PH1. The manufacturer claims its snap action provides a good "feel" of the switching action. It is protected against chemicals and chips. *Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Circle No. 39 on reply card



"Bill, I wish you'ld be more specific when you order parts through 'purchasing'."

ELECTRONICS IN CONTROL



DECADE CAPACITOR panel mounts with single dial.

A decade capacitor providing 1,000 incremental steps of 0.01 microfarads each yields a full range of 0 to 1 microfarad within plus or minus 1 per cent error. Each concentric ring of the dial establishes another decade range. Fully shielded, the 3 in. dia and 6 in. deep unit panel mounts with a threaded shaft sleeve in a single ⅞ in. panel hole. *Electro-Measurements, Inc., 4312 S. E. Stark St., Filmore 9235, Portland 15, Ore.*

Circle No. 40 on reply card

MAGNETIC AMPLIFIERS regulate line voltages.

An extensive new line of magnetic amplifier power regulating equipment is being heralded by new four models. They are intended for use as voltage regulators in large, sensitive equipment. Full information, including mechanical configuration is obtainable in the company's catalog, MVR1. *Sorenson & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Characteristics

Input voltage range.....95-130 vac, single phase, 60 cycles
Output range.....115 vac, rms, single phase
Regulation error....plus or minus 0.5 per cent against line changes
Load conditions.....from 0 to full with plus or minus 0.5 per cent error
Time constant....From 2 to 6 cycles for line changes

Circle No. 41 on reply card

First in performance for automatic muscle jobs like these...

T-J Spacemaker CYLINDERS

OFF SHELF DELIVERY

PUSH

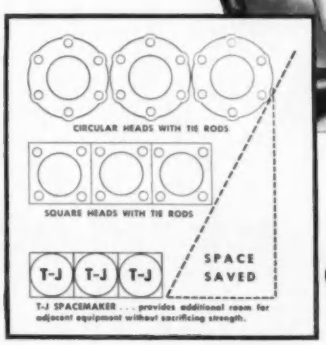
PULL

LIFT



- OIL pressure to 750—AIR to 200 P.S.I.
- New Compact Design . . . Saves up to 40% Space
- Proven Performance . . . with Extra High Safety Factor
- Super Cushion Flexible Seals for Air . . . New Self-Aligning Adjustable Oil Cushion
- Hard Chrome Plated Bodies and Piston Rods
- The Only Cylinders with all the Extras as Standard

T-J Spacemaker Cylinders get first call for an ever-widening range of power movement jobs in industry today—because they're so advanced in design . . . so efficient and dependable in performance. Wide selection of styles and capacities. Check your needs now! Send for bulletin SM-454-2. The Tomkins-Johnson Co. Jackson, Mich.



Raise	Open
Lock	Time
Brake	Blank
Press	Cut
Spin	Broach
Turn	Drill
Grind	Sequence
Weld	Close
Lower	Snub
Squeeze	Form
Bend	Pierce
Coin	Feed
Saw	Mill
Tap	Convey
Index	etc.
Braze	

Member of the National Fluid Power Association

T-J TOMKINS-JOHNSON
RIVITORS . . AIR AND HYDRAULIC CYLINDERS . . CUTTERS . . CLINCHORS

Relay Engineering Principles . . . #1

LISTEN!



. . . and relays will tell you how good they are

Try this experiment. Hold a relay to your ear. Snap the armature and listen! Did it sound like a harp, or did you hear a solid thud? A GOOD RELAY WILL NOT SING. Singing contact springs indicate excessive bouncing, vibration and overtravel, added arcing and mechanical wear, plus inaccuracy of contact adjustment.

To date, contact support springs have been found the most effective means of supplying sure control to meet the requirements listed below:

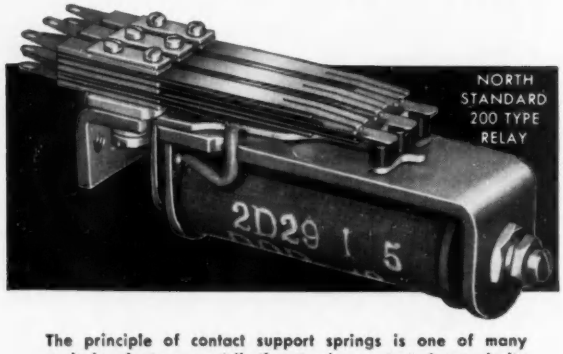
1. Minimized contact bounce. Impact energy of operation is immediately damped by friction between contact spring and its associated support spring.

2. Reduced arc damage. Higher rate of contact separation and closure with consequent reduction in arc time.

3. Decreased overtravel. Pre-tension of contact springs against the support springs provides proper contact pressure with minimum travel after closure. Thickening of contact springs is not a proper alternative as this tends to increase the frequency of contact chatter and bounce without providing suitable frictional damping to minimize arcing and mechanical wear.

4. Less mechanical wear. Motion means wear. Support springs provide adequate contact pressure without excessive spring flexure, thus increasing relay life.

5. Increased sensitivity of adjustment. Reduced spring overtravel permits a smaller armature air gap for greater over-all sensitivity.



The principle of contact support springs is one of many exclusive features contributing to the use-tested superiority of performance in North Relays of the type shown above. Some specific control type switching applications are safety controls — switchboards — elevator controls — power control circuits — carrier application — intercommunication systems — fire alarms — airport lighting controls and computers.

Have you received your copy of NORTH'S NEW RELAY CATALOG?

THE NORTH ELECTRIC MANUFACTURING COMPANY

Originators of ALL RELAY Systems of Automatic Switching

528 South Market Street, Galion, Ohio, U.S.A.

NEW PRODUCTS

MAGNETIC AMPLIFIER regulates power for 6 v, 5 amp.

Perkins latest tubeless power supply has a 6 v output, plus or minus 10 per cent, at 5 amp through line changes of 95 to 130 v and load changes from 10 per cent to full load. Maximum ripple is 1 per cent. *Perkin Engineering Corp., 345 Kansas Street, El Segundo, Calif.*

Circle No. 42 on reply card



DECADE DELAY has hermetically sealed elements.

Delay elements are hermetically sealed in epoxy resin in this new decade delay line. Ceramic wafer switches with solid silver contacts are used in the units, designated GDDL-1000-1. *The Gudeman Co. of Calif., Inc., 9200 Exposition Blvd., Los Angeles 34, Calif.*

Characteristics

Size	$7\frac{5}{8}$ by $4\frac{3}{8}$ by $4\frac{3}{8}$ in.
Overall delay	1 microsec
Tap interval	0.1 microsec
Impedance	1,000 ohms
Overall rise time	0.1 microsec

Circle No. 43 on reply card

PAPER-THIN tinkertoy resistors resemble printed counterpart.

Evolved from Project Tinkertoy thinking, a new line of resistors about one third the size of a paper match can be used in building prototype printed circuits and tinkertoy assemblies. Conventional tinkertoy techniques print resistors directly in the circuit, making changes very difficult.

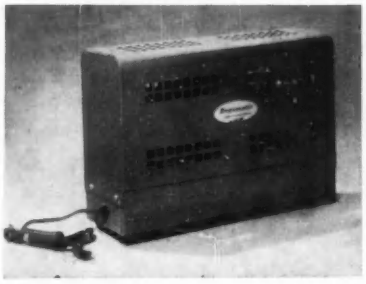
These new paper-thin resistors, however, allow convenient solder replacement. The manufacturer supplies a kit, No. PT-10000, for the construction of tinkertoy prototypes. The new resistors, type RTW, are available through a range of 39 ohms to 4.7 megohms, type RNP, from 100 ohms to 1 megohm, with tolerances of 5 and 10 per cent. Complete data and samples are available. *Hansen Electronics Co., 7117 Santa Monica Blvd., Los Angeles 46, Calif.*

Circle No. 44 on reply card

SHIFTED OUGHTS and decimals blaspheme new product.

In our December issue New Product Item No. 6 appeared to be a perfectly fine magnetic amplifier power supply. However, two glaring typos rendered a very useful product into something of unknown function. We listed the instrument as having an output voltage of 60 vdc with a load range of 0.5 amps. Actually, the rating is 6 vdc at 0-5 amps. *Sorenson & Co., Stamford, Conn.*

Circle No. 45 on reply card



REGULATES TV and laboratory voltages.

Although intended for consumer use with TV sets, the Regomatic's near-$30 price, and convenient size might make it desirable for many laboratories needing a constant-voltage source for 200 or 300 watt equipment. Plus or minus 3 per cent at 115 v regulation with a 95-to-130-v input is claimed. *CBC Electronics Co., Inc., 2601 N. Howard St., Philadelphia 33, Pa.*

Circle No. 46 on reply card

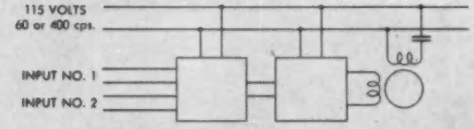
RATEMETER, SCALER of high speed pulses.

Counting a predetermined number

NEW!
MINIATURE
SERVO
Magnetic Amplifiers



Three New AC Servo Types Available..



STANDARDIZED SERVO SYSTEMS AND OTHER STANDARD TYPES FOR AUTOMATIC CONTROL —

In addition to new lines illustrated, many standard and higher power magnetic amplifiers are available for applications involving automatic control.

CUSTOM DESIGNS FOR SPECIAL REQUIREMENTS

— we design and engineer complete servo or automatic control systems

● MAGNETIC PRE-AMP + SATURABLE TRANSFORMERS
Supply: 115 volt 400 cps.
Power output: 3.5, 6, 10, 18 watts
Sensitivity: 1 volt AC
Response Time: .03 sec.
Lowest Cost — Smallest Size
For further information request Form S493

● MAGNETIC PRE-AMP + HIGH GAIN MAGNETIC AMPLIFIER
Supply: 115 volt 400 cps.
Power output: 5, 10, 15, 20 watts
Sensitivity: .1 volt AC
Response Time: .008 to .1 sec.
Highest performance — All magnetic
For further information request Form S496

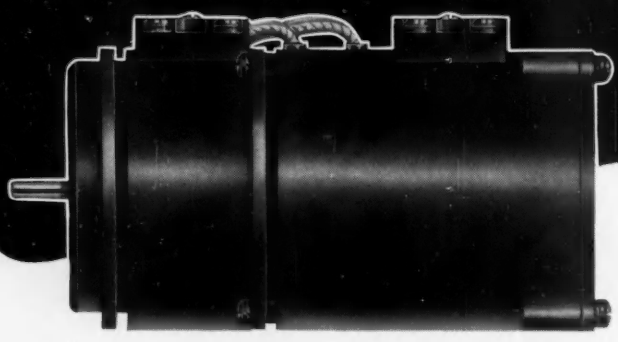
● TRANSI-MAG*: TRANSISTOR + HIGH GAIN MAGNETIC AMPLIFIER
Supply: 115 volt 400 or 60 cps.
Power output: 2, 5, 10, 15, 20 watts
Sensitivity: .08 volt AC into 10,000 ohms
Response Time: .01 sec.
Fast response at high gain
For further information request Form S499 (400 cps.); Form S497 (60 cps.)
*TRADE NAME

AFFILIATE OF THE GENERAL CERAMICS CORPORATION

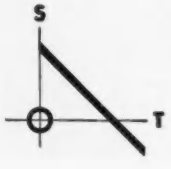
MAGNETIC AMPLIFIERS • INC
Telephone: CYpress 2-6610
632 TINTON AVE., NEW YORK 55, N. Y.

Tachometer Feedback

with Instrument Servo Motors



and now, a DIEHL Instrument Servo Motor and Integrally-Mounted Alternating Current Tachometer-Generator assures stability in a Servo loop. Designed for simple and easy mounting and can readily be adjusted after installation so that the in-phase residual voltage is essentially zero. A high impedance control-phase winding is available for plate to plate operation. 57½/57½ volt control-phase windings can be provided for magnetic amplifier applications. Diehl Motor-Tachometer combinations are obtainable with Gear Reducers in 5 different ratios. Attractively priced for commercial applications.



Visit us at
BOOTH 3
Kingsbridge Palace
Radio Engineering Show
March 21-24

MOTOR RATINGS	TACHOMETER SPECIFICATIONS	
1, 5 and 10 watts output	Input (volts)	115
GEAR REDUCTION RATIOS	Frequency (cycles)	60
191.1 to 1 76.6 to 1 32.4 to 1 13.8 to 1 5.8 to 1	Output (volts per 1000 RPM)	5.5
	Linearity	1%

Our engineering staff will gladly help you select the equipment best suited to your requirements. A request on your letterhead will bring you a copy of Technical Manual No. CT-355 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO.
Finderne Plant, SOMERVILLE, N. J.

NEW PRODUCTS

of pulses during a variable time, or a variable number of pulses during a fixed time gives a new instrument by Curtiss-Wright the facility of measuring the value or rate of change of pulse frequency. Used with Geiger tubes and scintillation counters, it can find rates of increase or decrease in the strength of radioactive materials. Serving as both ratemeter and scaler, the instrument is housed in a 26-by-19-by-10-in. cabinet and is adjustable for voltages from 300 to 3,000. Its maximum counting speed is 200,000 impulses per sec, with a maximum of 3,999,999 per sequence. *Curtiss-Wright Corp., Wood-Ridge, N. J.*

Circle No. 47 on reply card



RECYCLING COUNTER repeats at 30kc

Automatic recycling of a preset count increases the utility of this counter. Recycling at speeds of up to 30 kc enables it to act as a precise time-interval generator when input is an accurate time pulse rate. It then acts as a frequency divider, with the divisor being the preset count, the quotient being the recycling pulse. Our last issue mentioned at Flow Digitizer by Potter with roughly similar function and operation, namely the conversion of one digital rate into another slower one. The above counts from 0-9,999 at 30 kc when recycling, but up to 100 kc when used as a straight counter. Its recycling circuit can activate an internal relay. *Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio*

Circle No. 48 on reply card

LEAD NETWORK adjusts at low frequencies for servos.

Packaged in a small rugged case, a new adjustable lead network called the DCA-1 is aimed at the servo engineer, experimenter, and manufacturer. DC gain and phase lead do not affect change of the lead angle, which is

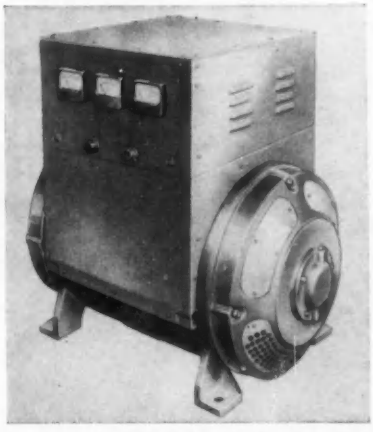
accomplished by a single control adjustment. *Computer Development Corp., 134-43 231 St., Laurelton, N. Y.*

Characteristics

Peak phase shift.....60 deg
Range of adjustment....5 to 15 cps
Attenuation at dc.....20 db
Attenuation at high freq.....0 db
Source impedance.....below 500 k

Circle No. 49 on reply card

MOTORS AND MOTION



400-CPS MOTOR-GENERATOR for avionic tests.

A synchronous motor drives the generator of this unit to provide an output of exactly 400 cycles, regardless of load or line voltage variations. Use for the unit is in the development or test of aircraft electronic gear. The voltage-control system has magnetic amplifiers, selenium rectifiers, and static sensing circuits to give stable voltage throughout the life of the generator without maintenance. *Palmer Electric Mfg. Co., 6629 Bear Ave., Bell, Calif.*

Characteristics

Motor speed.....1,200 rpm
Type.....6-pole motor and 40-pole alternator
Input.....3 phase, 60 cycle, 120/440 or 120/208 v
Output...5 to 100 kw, 0.8 P.F. single or three phase
Error.....plus or minus ½ per cent
Response time.....0.015 to 0.15 sec
Harmonic content.....0.25 per cent

Circle No. 50 on reply card

A HIGH PERFORMANCE MAGNETIC SERVO AMPLIFIER

-expressly designed for high temperature Mark 7 and 8 Servo Motor applications



Features of the PRD Type R40G10W1 Magnetic Amplifier:

- Response time of one cycle
- Temperature range −55°C to +85°C with normal servo duty cycles
- Hermetically sealed reactor unit only 2½" high and 2¼" diam., weighs less than 12 oz.
- Power supply 115V ±10%, 400 cps ±10%, single phase
- Rugged design meets MIL-5272 Procedure I Vibration Spec.

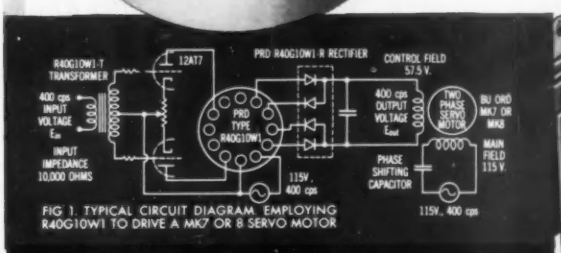
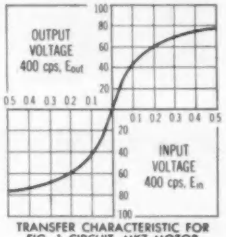


FIG 1. TYPICAL CIRCUIT DIAGRAM EMPLOYING R40G10W1 TO DRIVE A MK7 OR 8 SERVO MOTOR



Specify this improved Magnetic Amplifier for Miniaturization plus!

The R40G10W1 can be supplied as illustrated or with built-in magnetic, transistor, or vacuum tube pre-amplifier. In all cases, no additional power supply is required. The moisture and fungus proofed rectifier is supplied for external mounting. Containing a minimum number of components, the R40G10W1 assures the utmost in ruggedness and long, trouble-free life at minimum cost. It is ideal for use in servo systems requiring up to 10 watts amplifier output such as the control phase of Mark 7 and Mark 8 servo motors. Write for information on the R40G10W1 or send your specifications for applications of magnetic servo amplifiers, low level amplifiers, or regulators of voltage, frequency, speed, and torque.

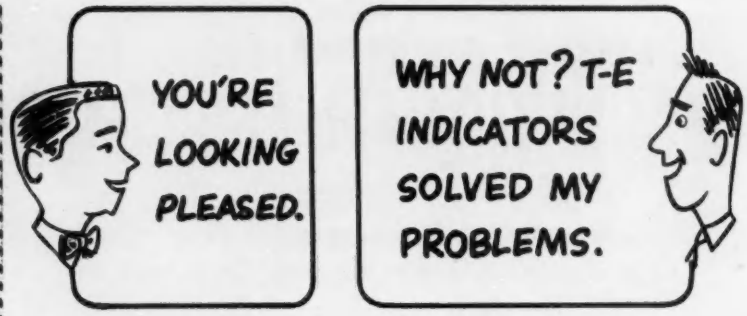


TRANSFER CHARACTERISTIC FOR FIG. 1 CIRCUIT, MK7 MOTOR

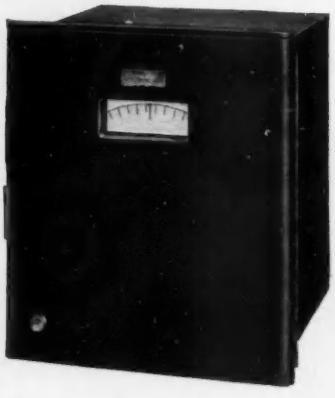
Polytechnic RESEARCH & DEVELOPMENT CO • Inc

Telephone: ULster 2-6800

202 TILLARY STREET, BROOKLYN 1, N.Y.



If you want to read temperatures accurately, use a T-E indicator: self-balancing or manual-balance, whichever suits your operation. Both of them are made in 2 types, potentiometer pyrometer and resistance thermometer. They are rugged, simple in design, and easy to maintain. 23 ranges from −320° to +200°F all the way to 0 to 3000°F. Connections are made through toggle switches, rotary switches, or quick-coupling connector panels.



SELF-BALANCING INDICATOR

For checking many points rapidly. Easy to read (34" scale with widely spaced graduations), fast (full scale travel 4 seconds), sensitive (1/20 of 1% of scale range), and accurate (± ¼ of 1% of range).



MANUAL-BALANCE INDICATOR

For research and testing applications. Extremely sensitive (resistance thermometer type can measure changes as small as 0.02°F) due to its electronic galvanometer, accurate (better than ¼ of 1% of scale), and rugged.

Write for details:

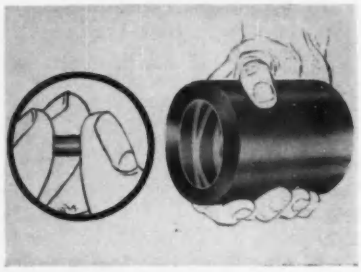
Self-balancing indicator, bulletin 61-B
Manual-balance indicator, bulletin 63-B

Pyrometers • Temperature Monitoring Systems • Thermocouples • Protection Tubes
Quick-Coupling Connectors and Panels • Thermocouples and Extension Wires

Thermo Electric Co., Inc.

SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

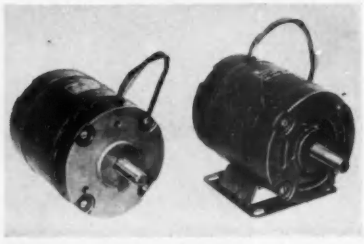
NEW PRODUCTS



NYLON FILM inside bearings lower friction, heat.

Metal bearings with a nylon lining 0.005 in. thick rapidly dissipate generated heat to guard against deformation of the nylon. Bores as small as $\frac{1}{32}$ in. are available with the tolerance for bore, concentricity, length, and outside diameter plus or minus 0.0002 in. *Nylacore Corp., 305 East Shore Road, Great Neck, N. Y.*

Circle No. 51 on reply card



SMALL, LIGHT MOTORS feature high torque.

A built in "air conditioner" enables a new line of miniature motors to deliver $\frac{1}{8}$th hp in a frame $4\frac{3}{8}$ in. OD

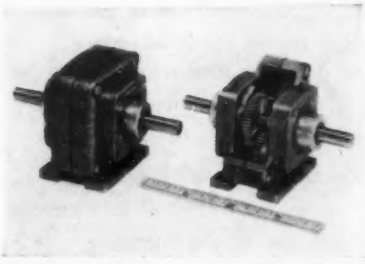
FEEDBECK FANCY

Needed: Rapid and effective means for keeping industrial noise in trim.

Suggested: Accoustical pickups mounted by moving units, which will scan and target on a "sound-control" panel any noise before its unduly offensive.

by 5½ in. long during continuous duty Class 'A' service. Hysteresis and induction types are available conforming to many MIL specifications. The maker cites their adaptability to differing requirements, including extra-high torque intermittent-duty cycles. *Instrument Motors, Box 5 Acosta St., Stamford, Conn.*

Circle No. 52 on reply card



NO BACKLASH and 600 standard speeds with reducers.

Spring-loading parallel gear trains eliminates backlash in the Series 11 Bantam Speed Reducer. The adjustable antibacklash torque spring provides a maximum of 2 lb-in. in either direction. Obtainable in 600 standard ratios using 48 pitch hardened gears, they are intended for flow controls, graphing devices, computers, etc. *Metron Instrument Co., 432 Lincoln Street, Denver 3, Colo.*

Circle No. 53 on reply card

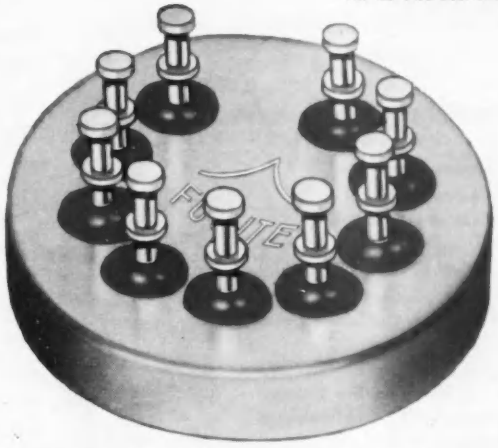
FEEDBACK FANCY

Needed: A magazine which will specialize in motorcycle, bicycle, and adding machine technology.

Solved: Those intrigued by the possibilities inherent in the unity of these fields should apply for a subscription to INFORMATSIONNYI BIULLETIN' GLAVNCO UPRAVLENIIA ZAVODOV MOTOTSSIKLETNO - VELOSIPEDOI PROMYSCHLENNOSTI I SCHETNYKH MASHIN (normally restricted to subscribers in the USSR), which, we are informed through usually well-informed sources, is devoted to the science of the motorcycle, bicycle, and adding machine.

Introducing FUSITE'S New T.P.* Terminals with V-24 GLASS

* **TORTURE-PROOF**
(Don't take our word for it. You test them.)



Fusite's exclusive new V-24 Glass, developed in our lab., smelted right in our own plant is now permitting us to offer features in our entire line of hermetic terminals that we've long dreamed of, never 'til now realized.

Check these construction and performance features:

- ☑ **100,000 Meg. Ohms at 150° C.**
- ☑ **Extreme Resistance to Thermal and Mechanical Shock.**
- ☑ **Greatly Improved Flash-over.**
- ☑ **Hot Solder Dipped for Better Salt Spray Resistance and Easy Soldering.**
- ☑ **Stronger Low Expansion Alloy Pins in Light-weight Cap.**
- ☑ **Remain Leak-proof through Years of Use and Abuse. (Test 'em on Your Mass Spectrometer Leak Detector!)**

Write Dep't. N-1 today for free samples for testing. Specify Fusite V-24 Glass.

FUSITE TERMINALS

THE FUSITE CORPORATION
6000 FERNVIEW AVENUE
CINCINNATI 13, OHIO

IBM news

TRADE-MARK

FOR ENGINEERS

MARCH'S BIG CAREER OPPORTUNITIES

DEVELOPMENT ENGINEERING*

Digital computer component development – design of components and functional units of accounting and data processing machines – transistors and transistorized units – special electron tubes–counters–magnetic core, drum, tape, and ferro-electric storage devices. ALSO fine openings in digital computer circuit design, electro-mechanical development and systems planning and analysis.

MANUFACTURING ENGINEERING*

Design and development of electronic test equipment for digital computer production testing–circuit design–systems planning and analysis–test planning. ALSO excellent openings in functional and acceptance testing–test equipment installation and maintenance–automation engineering–manufacturing research.

***Required** – a degree in E.E., M.E., or Physics, or equivalent experience.

Desirable – experience in any of the following fields: digital and analog computers, including airborne types, radar, TV, communications equipment, relay circuitry, automation, servo-mechanisms, instrumentation, or data handling systems.

APPLIED MATHEMATICS**

IBM seeks a special kind of mathematician and will pay well for his abilities. You'll work as a special representative of IBM's Applied Science Division as a top-level consultant to business executives and scientists. Employment assignment can probably be made in almost any major U.S. city you choose.

****Required**: major or graduate degree in Mathematics, Physics, or Engineering with Applied Mathematics equivalent. Desirable, but not required, experience in teaching Applied Mathematics and use of automatic computing equipment.

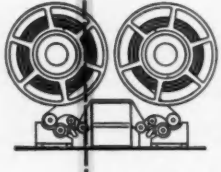
"I'VE GROWN WITH IBM"

says Wallace D. Bolton, Development Engineer at the Endicott Laboratories



"The way IBM is growing certainly offers a young engineer the opportunity to move ahead–and in work that's interesting," says Wally. "Since I joined IBM in July of '50, right after getting my BS/EE from the University of Pennsylvania, I've been closely associated with a new development in the field of high-speed printing. Now, I'm in charge of the research phase of this program. And in just about every other area around me, I've seen opportunities opening up all the time for other young engineers."

IBM MAGNETIC TAPE DEVELOPED BY ADVANCED ENGINEERING



The great data processing machines produced by IBM employ the latest advances in processing and data storage. Among these is oxide-coated acetate tape used to record information in the form of magnetized spots. Tape units for either reading or writing operate at a rate of 15,000 characters per second.

The density of recording is 200 characters per inch, permitting permanent files of data to be compressed onto a 10½-inch diameter reel holding 2,400 feet of tape. A single reel can contain over 50,000 grouped records of 100 characters each.

For information on these career opportunities

WRITE,

giving details of education and experience, to:
William M. Hoyt, IBM, Dept. 686(26)
590 Madison Ave., New York 22, N.Y.

Your replies, of course, will be held in strictest confidence.

INTERNATIONAL BUSINESS MACHINES CORPORATION

World's Leading Producer of Electronic Accounting Machines and Computers

JOIN YOUR FRIENDS AT

IBM

THEY'LL TELL YOU IT'S A GREAT PLACE TO WORK.

For More Information

from ADVERTISERS

FILL IN THIS CARD →

about NEW PRODUCTS

CIRCLE THESE NUMBERS →

to get NEW BULLETINS & CATALOGS

CIRCLE HERE →

THE NUMBER YOU SELECT HERE ↓

ADVERTISER	PAGE NO.

CONTROL ENGINEERING
MARCH 1955

NOT GOOD IF MAILED AFTER MAY 1, 1955

NAME .....

POSITION .....

COMPANY .....

ADDRESS .....

CITY AND STATE .....

Please print or type plainly

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49
50	51	52	53	54	55	56
57	58	59	60	61	62	63
64	65	66	67	68	69	70
71	72	73	74	75	76	77
78	79	80	81	82	83	84
85	86	87	88	89	90	91
92	93	94	95	96	97	98
99	100	101	102	103	104	105

CONTROL ENGINEERING
MARCH 1955

NOT GOOD IF MAILED AFTER MAY 1, 1955

NAME .....

POSITION .....

COMPANY .....

ADDRESS .....

CITY AND STATE .....

Please print or type plainly

(57) SENSITIVE OSCILLOGRAPH. Allen B. Du Mont Laboratories, A single-page bulletin with complete performance data on Type 325 oscillograph, which measures dc in the millivolt and even microvolt regions. The frequency response extends to 300 kc. Its use with strain gages without the need of preamplification is mentioned.

(58) DIFFERENTIAL TRANSFORMER CONTROL. Allen B. Du Mont Laboratories. Catalog No. 1725-K. One-page description of a differential transformer control with linearity of plus or minus 1 per cent, and a range of plus or minus 0.000025 to 0.1 in. when used with their new sensitive oscillograph, Type 325, which will measure microvolts. The transformer control contains a 20 kc oscillator, a differential amplifier for the secondary winding of the differential transformer, and a low-pass filter to remove the carrier from the signal information.

(59) LINEAR TORQUE MOTOR. Barber-Colman Co. A single-page bulletin on the characteristics and performance of a linear actuator for high-speed positioning of pilot valves in guided missiles or other fast servo systems. Controlled by a small electrical signal, this unit provides motion through plus or minus 0.025 in., with a force output of 5.3 lb. at 60 ma. differential current.

(60) RELAYS. Advance Electric and Relay Co. Catalog. 4 pp. A compact listing of relay contact arrangement, operating power, coil resistance, size, etc., plus pictures and brief descriptions for 48 different types, including latching, very sensitive, and time delay.

(61) SOLENOID VALVES. J. D. Gould Co. Bulletin F-1. Prices, pressure ranges, sizes, and performance characteristics of low-cost direct-lift solenoid valves for use with air, gas, water, oil, and steam.

(62) CONNECTORS. DeJur-Amsco Corp. Two bulletins show construction of 6-contact receptacle and plug, "FHL" model, and "HC-20" 4-, 5-, 7-, 9-, and 10-contact plug and socket connectors.

(63) FURNACE THERMOCOUPLE. Leeds & Northrup Co. Sheet 643(1) 4 pp. Performance, construction, and application data on a thermocouple and associated recorder for use with open hearth and electric furnaces to measure bath temperatures.

(64) RELAY SELECTION. Automatic Switch Co. Bulletin. Gives indexed data on relays for various applications, and available technical bulletins from the maker which cover the desired applications.

(65) STRAINERS. Schutte and Loerting Co. Bulletin 9-S. 16 pp. Provides application and design data on strainers for all types of applications. Dimensions and selectional views.

(66) MINIATURE VACUUM TUBE VOLTMETER. Trio Laboratories. Four bulletins. Descriptions and performance data on miniature panel-mounted vacuum tube voltmeters and auxiliary power supplies.

(67) MATERIAL ANALYSIS. North American Philips Co. Autrometer folder. 4 pp. Describes the principle and operation of the Autrometer for automatic analysis of incoming raw materials, process constituents, and finished products. Full-page color diagram shows how the whole thing works.

(68) RECORDING SPECTROPHOTOMETERS. Allied Physics Corp. Catalog. 16 pp. Describes performance, construction, accessories, and modifications on the company's recording spectrophotometers for ultra-violet, visible, and infra-red spectra recording. Also mentions raman spec-

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 64, (Sec. 34.9, P. L. & R.) New York, N. Y.

Reader Service Department
CONTROL ENGINEERING
330 West 42nd Street
New York 36, N. Y.

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 64, (Sec. 34.9, P. L. & R.) New York, N. Y.

Reader Service Department
CONTROL ENGINEERING
330 West 42nd Street
New York 36, N. Y.

trograph, electrometers, infra-red and ultraviolet Analyzers.

(69) MAGNETIC AMPLIFIERS. Federal Telephone and Radio Co. 4 pp. Provides some characteristics and application illustrations of the company's magnetic amplifiers.

(70) AUTOMATIC CONTROL EQUIPMENT. Zenith Electric Co. Catalog, 32 pp. Performance details, photographs, and prices of automatic transfer switches, remote control switches, magnetic contactors, reversing controls, stock relays, solenoids, motor controls, program, interval, and reset timers.

(71) MAGNETIC CORES. General Ceramics Corp. Specifications and data sheet. 4 pp. Curves and detailed magnetic properties of Ferramic "Q", especially when used as toroidal ring, core, and rod.

(72) SUPERSENSITIVE PHASE SHIFTER. Brownthron Electronics Inc. Technical Bulletin 101, 13 pp. Describes applications and circuit details of the company's phase shifter for use with thyrathron and mercury pool rectifiers. Provides detailed performance data and application circuits.

(73) VOLTAGE REGULATOR. General Radio Co., Form 874-A, 4 pp. Gives basic performance figures and prices for a voltage regulator using a servo operated Variac, for error within 0.25 per cent.

(74) CABLE CONTROLS. Teleflex, Inc. Bulletin 500, 16 pp. Describes mechanical controls, linkages, and mechanisms using a rack-like flexible cable within a smooth, rigid conduit. Worksheets suggest applications.

(75) MECHANICAL COUNTER. Raycon Corp. Form 550-1054, 1 pp. Provides details on low-cost dial-type counter which has top rate of 3,000 units per min in a case 3.5 in. diam. Counts to 999,999 and can be flush mounted.

(76) PILOT LIGHTS. Dialight Corp. Form. 1-157 pp. Describes one-terminal subminiature pilot lights for use with grounded circuits. All require $\frac{11}{32}$ in. mounting holes.

(77) MICRO SWITCH. Minneapolis-Honeywell Regulator Co. Catalog No. 62, 28 pp. Listing and characteristics of over 400 basic switches, auxiliary actuators, and terminal enclosures. Also available is catalog No. 75, featuring subminiature switches and auxiliary actuators for them.

(78) VOLTMETERS. Arga Div., Beckman Instruments, Inc. 4 pp. Describes and gives figures on a line of expanded scale voltmeters, with spans from 4 per cent to 25 per cent of base voltage.

(79) SMALL DC MOTORS. Barber-Colman Co. Catalog F-4344-1. 19 pp. Provides all significant data on their line of small motors in the $\frac{1}{76}$ hp range, with OD's of about $1\frac{1}{2}$ in.

(80) AC-TO-DC CONVERTER. Quare Associates, bulletin, 4 pp. Describes performance and application circuits for this ac-to-dc-to-ac converter, with error of less than 0.05 per cent. When converting from dc to ac, a square wave is generated.

(81) ELECTRONIC COMPONENTS. Centralab, Catalog No. 29, 48 pp. This is the 1955 catalog of Centralab's capacitors, Snap-Tite Controls, etc.

(82) X-Y RECORDER. Leeds & Northrup Co., Data Sheet E-ND46 (1), 2 pp. Describes "Speedomax" X-Y recorder for line recording of temperature vs elongation, stress vs strain, motor and engine performance, etc. This is a typewriter-sized panel-mounted 10-in.-Y-axis recorder.

(83) SERVO COMPONENTS. Feedback Controls, Inc., 9 pp. brochure. A catalog of the company's servo amplifier, servo systems, magnetic servo amplifiers, and booster amplifiers.

(84) GAS REGULATORS. Victor Equipment Co. Form 341-CW-4-54, 15 pp. Describes and provides complete performance data on gas-pressure regulators.

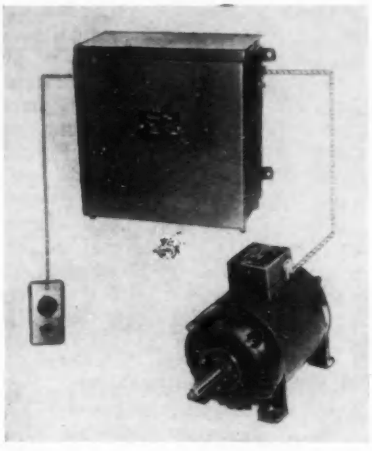
(87) POTENTIOMETERS. General Radio, Form 866-A, 8 pp. A description of mechanical details of construction, performance, characteristics, and prices of the new 970 series high-quality low-cost potentiometers. Stock resistances range from 2 ohms to 500,000, wattages from 2 to 20, with linearities from plus or minus 0.2 per cent, and prices from $3.15. This bulletin opens up to form a wall-sized chart, giving dimensions of eight different stock sizes, power rating vs temperature charts for each, and accuracy figures.

(88) POWER OPERATORS. Conoflow Corp., Bulletin B-50-2, 12 pp. A pneumatically positioned power operator for throttling control service is described with its application to speed changers, valves, pumps, and electrical components.

(89) HYDRO-AIR POWER PACKAGE. Pantex Mfg. Corp., bulletin, 16 pp. Describes and provides characteristics and price of a prize-winning power unit which combines the fast response of pneumatic devices with the power and accuracy of hydraulic cylinders. Full mounting information is provided.

(90) TAPE PUNCH. Teletype Corp., catalog, 8 pp. Provides photographs and drawings of tape punching and reading machines, with full performance characteristics. Punch operates at 60 characters per sec., with 5-, 6-, or 7-hole codes.

(92) FLOW CONTROL. Sparling Meter Co., Bulletin 313, 19 pp. Lists, describes a complete line of flow meters, direct and remote reading, proportional blenders, recorders, indicators and totalizer, and controls. This is a complete line, primarily for water control, but much of it appropriate to and intended for oils and other fluids.



LOW COST tachometer feedback speed control.

Feedback from a tachometer enables constant speed per setting in this speed-control set. First of a series, the presently available ¼ and ½ hp models can be varied with constant torque throughout a speed range of 30:1. The electronic control features epoxy resin potted plug-in units to reduce part replacement to a screwdriver operation. Either 1,800 or 3,600 rpm base motor speeds are sold. The under-$200 price of these units is also noteworthy, says the maker. *Servo-Tek Product Co., Inc., 1086 Goffle Road, Hawthorne, N. J.*

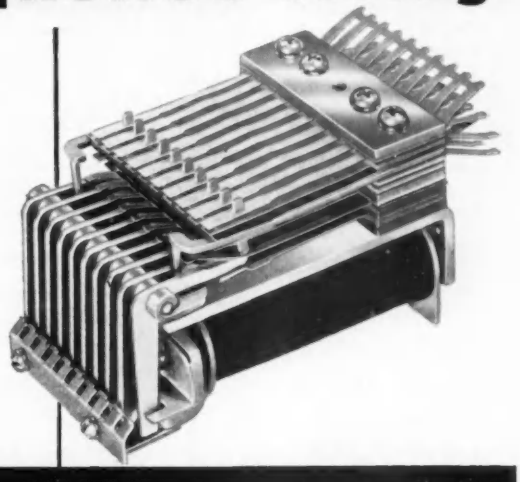
Circle No. 54 on reply card

FEEDBACK FANCY

Needed: An automatic martini mixer to speed commuters to the 5:10.

Suggested: Why not chromed coin bartenders? The 3:1 or 4:1 gin-vermouth ratio can be dialed, the olive or onion button pushed, and half dollar inserted. And if local authorities balk, why not this as a home remedy to the normal wifely aversion to cocktail mixing? Incidentally, since the proposed vender will certainly use Dixie Cups, it could be appropriately rigged to dispense mint julips.

RUGGED COMPACT KELLOGG Sequence Relay



THE MAGNETIC IMPULSE COUNTER

- 10 INDIVIDUAL ARMATURES
- LIFE EXPECTANCY OVER ONE HUNDRED MILLION PULSES
- PRECIOUS METAL CONTACTS PALLADIUM OR GOLD ALLOY
- RELIABLE
- WIDE RANGE OF APPLICATIONS
- NORMAL DELIVERY—15 DAYS

A Famous Name in Communications Now Solving Problems in the Control Industry

KELLOGG DIVISION OF IT&T
Industrial Sales Department

KELLOGG SWITCHBOARD AND SUPPLY COMPANY
A Division of International Telephone and Telegraph Corporation
Sales Offices: 79 West Monroe Street, Chicago 3, Illinois

KELLOGG SWITCHBOARD AND SUPPLY COMPANY
79 West Monroe Street, Chicago 3, Illinois, Dept. 72-C

☐ Please have representative call

☐ Please send detailed information on the Magnetic Impulse Counter

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

AUTOMATIC FEEDBACK CONTROL SYSTEM SYNTHESIS

Just Published!

Advanced development of feedback theory putting partcular emphasis on synthesis of feedback control systems. Emphasizes use of the Laplace transform as a design tool, and reviews and unifies the mathematical background and basic theory forming the foundation for various analysis and design procedures. **By J. G. Truxal, Assoc. Prof. of Elec. Engr., Polytechnic Inst. of Brooklyn. 675 pp., 679 illus., $12.50**



Just Published!

SERVO-MECHANISM PRACTICE

A practical approach to handling the problems of servomechanism design, manufacture, and operation. Gives essential data on circuitry, electrical and mechanical components . . . shows what to do about these components to achieve the limit of their performance. Includes step-by-step design methods, manufacturing techniques, and trouble-shooting and testing procedures. Provides information on magnetic amplifiers and many other recent advances in servomechanism components **By W. R. Ahrendt, President, Ahrendt Instrument Co.; Lecturer, U. of Maryland. 341 pp., 282 illus., $7.00**

MAGNETIC-AMPLIFIER CIRCUITS

This practical treatment of fundamental principles, characteristics, and applications logically develops the various kinds of basic and more complex magnetic amplifier circuit arrangements without extended mathematical considerations. Descriptive and graphical methods are used to give qualitative and quantitative interpretation of essential facts. Material is systematically classified according to circuit functions so you can compare and select solutions best suited to your special problem. **By W. A. Geyger, U. S. Naval Ord. Lab. 277 pp., 135 illus., $6.00**

ANALOG METHODS IN COMPUTATION AND SIMULATION



Organized treatment emphasizing engineering and scientific applications. Describes mechanical, electromechanical, electrical, and electronic analog components and how they may be combined into mathematical machines for solving many types of equations. Covers such recent advances as schemes for multiplication of variables and the uses of high-gain feedback amplifiers. **By W .W. Soroka, Prof. of Engr. Design., U. of California. 400 pp., $7.50**

SEE THESE BOOKS 10 DAYS FREE

McGraw-Hill Book Co., Dept. CON-3
330 W. 42, NYC 36

Send me book(s) checked below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents delivery costs, and return unwanted book(s) postpaid. (We pay delivery costs if you remit with this coupon—same return privilege.)

☐ Truxal—**Auto Feedback Control System Synthesis—$12.50**
☐ Ahrendt—**Servomechanism Practice—$7.00**
☐ Geyger—**Magnetic-Amplifier Circuits—$6.00**
☐ Soroka—**Analog Methods in Computation and Simulation—$7.50**

(Print)
Name .....
Address .....
City .....Zone....State.....
Company .....
Position .....

For price and terms outside U. S. write McGraw-Hill Int'l., N.Y.C. CON-3

WHAT'S NEW ABSTRACTS

An Upright Queen

From "Recent Developments in Ship Stabilization," by J. Bell, Chief Research Engineer of Muirhead & Co., in "Muirhead Technique," January, 1955, Beckenham, England.

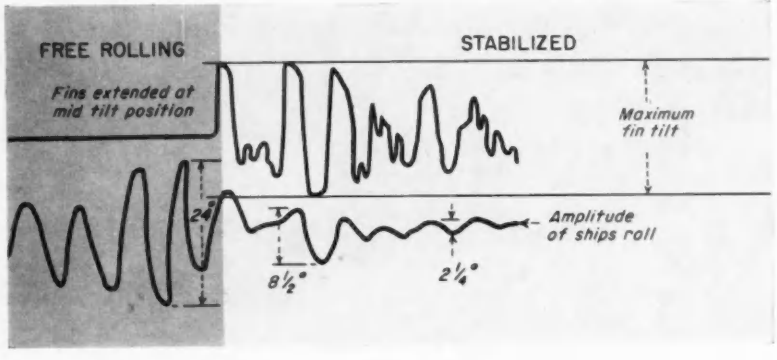
When the Queen Elizabeth arrives in New York on March 21, she will have made the crossing with a roll limited to plus or minus 3 deg., gales notwithstanding.

Although not spectacularly new, ship stabilization gear seems to be making accelerated headway. Muirhead & Co., Ltd. report 25 new orders for their stabilization gear. The overwhelming enthusiasm of ship owners for this type of machinery has been retarded largely by the substantial expense and space it requires. However, the effectiveness of the Muirhead equipment in smoothing out the waves is well demonstrated by the graph above, which shows that rolls of 24 deg. can be smoothed out to 8½ deg.

Mechanically, the stability actuators are four fins protruding from the side of a ship. Each has a pocket into which it can be withdrawn in good weather or when docking. Muirhead makes the stabilizing system, not the fins. The system consists of a gyro-controlled hydraulic actuator at each fin. Unless the effect of the sea is greater than that of the fins, the ship can be kept upright to within 2 or 3 deg.

Muirhead is a maker of servomotors, amplifiers, decade oscillators, tube-maintained tuning forks, frequency dividers, phase meters, and inkless chart recorders.

The power requirement of a stabilizing system on a medium-sized ship, such as an ice-breaker, is on the order of 30 hp. As far as retarding effect is concerned, tests have proved conclusively that the retarding effect of a substantial roll is just about the same as that of the stabilizing fins, and therefore, the power loss through their use is insignificant. In heavier seas, however, the stabilized ship can be operated at a higher speed than otherwise possible, and therefore has the added advantage of keeping to its schedule.



Medical Electronics

From "Electricity in Medicine," by S. N. Pocock, formerly with Edison Swan Electric Co., Ltd., "The Proceedings of the Institution of Electrical Engineers," December 1954, London.

Exactly what the rows of thin irregular lines down the strip of graph paper represent no one really knows. They are approximately sinusoidal, and differ in frequency from 1 to 50 cps. They originate in the brains of men, and to a lesser degree, in chimpanzees, and lesser still, dogs. But through studies of their characteristics in brains with known defects diagnoses of other brains are often quickly made. The instruments making the graphs are called electro-encephalographs. They are fast-responding, sensitive, multi-channel recording voltmeters. Input signals are on the order of 50 microvolts from peak to peak. Sensitivity available is on the order of 1 mm. of pen motion per microvolt. Response speed is plainly a problem, as are shielding and stable power supplies, especially since power line frequencies are in the range of

Control Gases to 10,000 P.S.I.

WITH VICTOR GAS-O-DOME REGULATORS



Gas pressure, not springs, control diaphragm motion to give you precise regulation of high-pressure gases at high or low flow rates. Can be remotely controlled if desired. Safety valve furnished on request. More than 55 stock models in the following series:

GAS-O-DOME SERIES	DELIVERY RANGE (p.s.i.)	SPECIAL FEATURES	GASES HANDLED
GD 30	0-2500	High Delivery Flow Rates. Accurate Valve Control.	Air, Argon, Helium, Hydrogen, Nitrogen, Oxygen —and others non-corrosive to bronze and stainless steel.
GD 31	0-3600		
GD 61B	0-2500	Excellent Capacity. Compact— 7 lb.— 4" x 6" x 6". —67° to +160° F. Range.	
GD 62B	0-3600		
GD 80	0-5000	Accurate Valve Control. —67° to +160° F. Range.	
GD 81	0-10000		
GD 10	0-500	Self-Relieving Pilot Regulator Control. High Flow Rates.	
SR 10	0-1000	High Pressure, Low Flow. Compact—4 lb. —2" x 6" x 6".	
SR 100	0-30 & 0-40	Corrosion Resistant.	Ammonia (wet or dry) Boron Trifluoride Chlorine (wet or dry) Hydrogen Sulfide, Hydrogen Chloride, Sulfur Dioxide—and other corrosive gases.

VICTOR'S LONG EXPERIENCE IN PIONEERING HIGH PRESSURE GAS REGULATION *is yours for the asking. For details, and complete data on Gas-O-Dome Regulators, see your VICTOR dealer or write us for catalog 341. Dealer inquiries invited.*

VICTOR EQUIPMENT COMPANY

Mfrs. of welding & cutting equipment, hardfacing rods; blasting nozzles; cobalt & tungsten castings.

844 FOLSOM ST. • SAN FRANCISCO 7 21

...EXAMINE THIS HOSE COUPLER...

will it help YOU?



Instant Free Flow

NEW

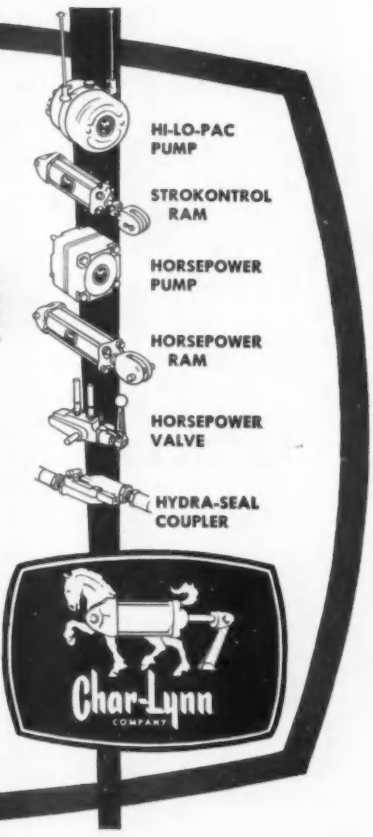
Char-Lynn

HYDRA-SEAL HOSE COUPLER

The Char-Lynn Hydra-Seal Hose Coupler has been engineered and designed as a quick-connect self-sealing, break-away coupler for all fluid carrying hoses.

Operation of the Hydra-Seal Coupler is as simple as inserting or removing a plug from an electrical outlet. To couple, hook on and push together; to uncouple, pull apart; no tools are needed. As the barrels are hooked over the slide lugs and the coupler pushed together, the barrels displace the slides and the barrel ports are brought into register or alignment . . . thus allowing the free flow of fluid through the coupler. Pulling the coupler apart brings the slides into position over the ports—oil is sealed in, dirt sealed out.

Let Char-Lynn solve your coupler problems.



CHAR-LYNN COMPANY

CE35 2843-26th Avenue South, Minneapolis 6, Minnesota

Hydraulic Horsepower To Serve You Better

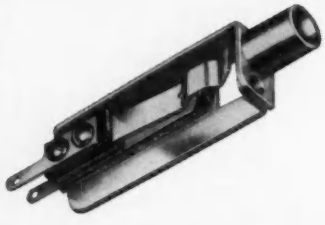
TELEPHONE TYPE

CINEMA *jacks*

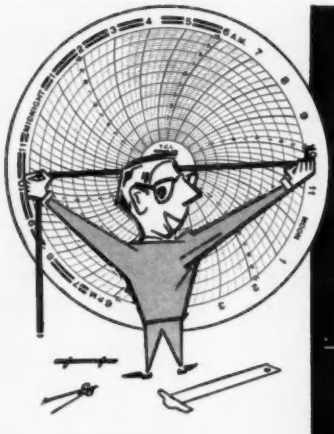
for

INDUSTRIAL CONTROL INSTALLATIONS

Industrial quality telephone type Jacks of 2 and 3 circuit types with additional switching arrangements. Write for catalogue on your letterhead.



CINEMA ENGINEERING CO.
DIVISION AEROVOX CORPORATION
1100 CHESTNUT ST. • BURBANK, CALIF.



charts made to your measure

When you need "Special" recording chart. . . . for measurements under unusual conditions, or for new instruments . . . call on Technical's chart specialists.

Technical will design and manufacture your charts using the same highly developed techniques employed in producing their supply of over 8000 standard chart items. Plates will be made from accurately etched wax engravings, charts will be printed on machines using the latest in electronic control of registration, and special paper will be selected to give you the recording results you require. Among Technical's "special" users are the U. S. Bureau of Standards, Bell Aircraft Corp., E. I. DuPont de Nemours & Co., Inc. and others.

To help you in planning for the right chart to fit your "Special" needs, Technical offers a bulletin with basic chart information for your file. Ask for your copy of "Technical Notes".

Serving America's Foremost Industries

TECHNICAL CHARTS, INC.
188 VAN RENSSELAER STREET
BUFFALO 10, NEW YORK
Nationally Represented by
TECHNICAL SALES CORP.
16399 Meyers Road Detroit 35, Michigan

ABSTRACTS

recording frequencies. Gain, from probe to pen, is on the order of 2 x 10^6. Noise-free first-stage tubes are not easily obtained. As a matter of fact, only 5 per cent of the best available type are usable.

Probes are put right on the outside of the brain proper, or are sunk into it with shielded probes. There are reasons why the use of as many probes as possible is desirable, and recorders with up to fifteen channels are available in France, although the average number is eight.

Over 100 electro-encephalographs are in use in the United Kingdom alone. One clever feature of many of these machines which might well be adapted to other long chart recorders is a mechanism which uses chart paper folded accordian-style, and after marking, refolds it. Hence, any point along the chart may be examined, like a book, while the machine is in operation, or afterward. A spectacular technique involves a portable multi-channel radio transmitter that can be strapped to the patient's back, enabling him to walk about with probes in his brain, transmitting signals back to the electro-encephalograph.

Medical electronic instruments can be roughly classified as those used for diagnosis and those for therapy. A second type of diagnostic instrument is the electrocardiograph. It records the action of pulsing muscles around the heart which display small electrical currents on the order of one microvolt from peak to peak. An interest in making these instruments portable has caused considerable experiment with marking methods, ranging from heated stylii, to jets of ink about 10 microns in diameter. Accoustic pickups have been experimented with, but frequency-vs-phase response characteristics of the transducer and writing pen have caused considerable difficulty. Oscilloscopes and photographic recording are not particularly well received because of the time lag between recording and record examination. Difficulties in presentation also have limited acceptance of miniature or microfilm graphing techniques.

Well known by now is the radioactive-isotope technique of observing the passage of material through the body, and the motion of various parts. The limited amount of radioactive material that can be safely introduced into the body requires highly sensitive indicating instruments.

Electromyography is the measure-

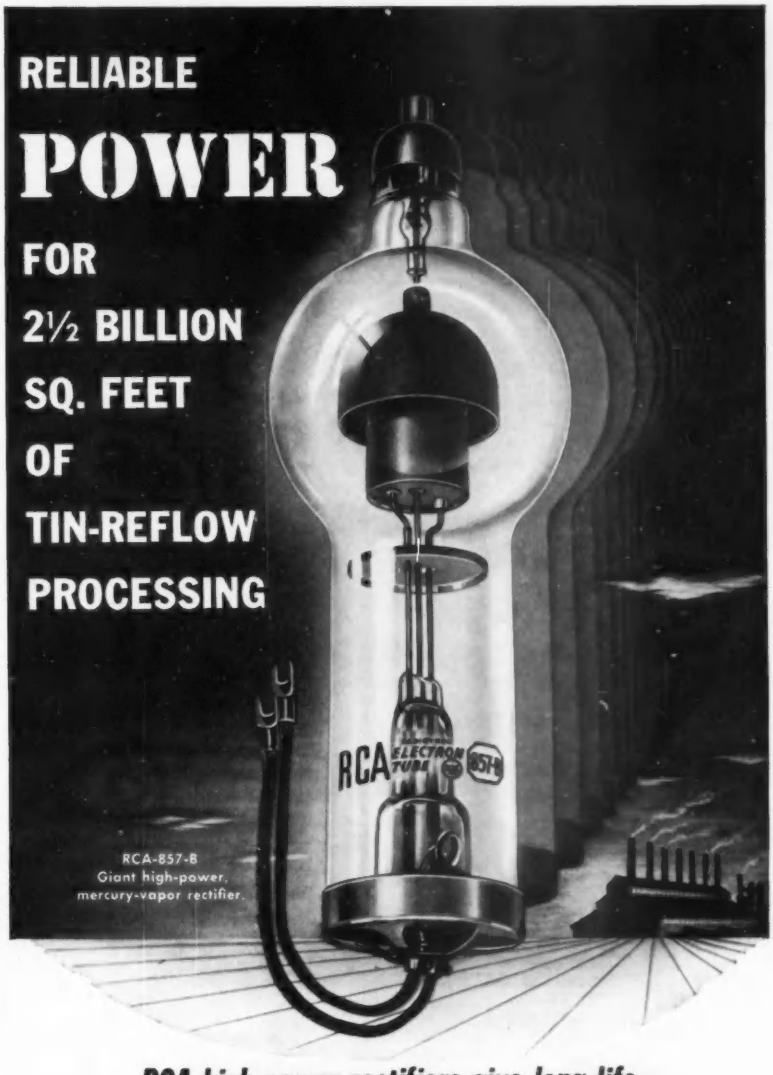
ment of nerve impulses within muscles, and "action potentials," as these characteristics vary from healthy to diseased. The pulses are sharply peaked at about one millisec. Oscilloscope display and recording are the tools most commonly used for this type of analysis.

Simple nerve stimulation by electric shock is valuable in analysing the passage of pulses through motor and sensor nerves in order to assay their condition. Electronic pulse generators, with finely adjustable pulse widths, are coming into popular use. Variable amplitudes and pulse frequency are required qualities.

On the therapy side, diathermy involves the generation of heat at specific points in the body. Very-high-frequency oscillators, in the 13 to 40 megacycle range are used, with coils for contact with the body.

Another means of inducing heat at a specific point is ultrasonics. A piezoelectric sound head, operated at about 1 megacycle, is put in direct contact with the body, with from 15 to 35 watts output. Most of the engineering difficulties associated with this type of equipment center about the design of the sound head.

The most spectacular electric therapy device is also, electrically, the simplest. The patient is firmly strapped into a chair onto a table, his forehead is dampened with a saline solution or a conductive jelly, a pad-shaped electrode is attached to each temple, and from 70 to 170 volts, at 50 to 100 cps are run through his forehead for 0.1 to 1 sec. The current will be between 0.2 and 1 amp., depending on skin resistance. Only a small fraction of this reaches the brain proper, but the effects are profound. Complete and immediate unconsciousness is followed within 5 to 15 minutes by severe convulsions. The major danger of shock therapy lies in the possibility of heart failure, arms and ribs being broken during the convulsive period. Usually the technique will not be used with a patient who is not in physically good condition. Mentally, the whole episode is generally erased, including a period of up to one hour before the treatment. Memory is confused and the patient is a bit bewildered. Subsequently, however, a relaxed, calm, and generally pleasant attitude prevails. Although very widely used, the exact nature of the cure is unknown. Universal success is not the rule. Theories that the treatment destroys parts of brain have been refuted to consider-



RCA high-power rectifiers give long-life service at Weirton Steel Company—a division of National Steel Corporation

Tin reflow on steel strip, averaging 30" in width, is achieved with amazing speed, quality, and economy at Weirton Steel by means of electronic heating. Moving at the rate of 1,300 ft. or more per minute, the steel strip passes through high frequency heating coils, fed by a group of 200 kw electronic oscillators, which reflow the tin, producing a high quality coating.

To supply the oscillator plate power for this high-speed electronic operation, Weirton uses 24 RCA 857-B's in two banks of 12 tubes each. This rectifier installation has given an average tube life of 12,000 hours...a period representing about 2½ billion square feet of strip production.

Here is another example of the way RCA Tubes are helping industry do a better job at lower cost.

* * *

When you need power tubes, rectifiers, ignitrons, thyratrons, computers, phototubes, or RCA Tubes of any type, call your RCA Tube Distributor. (He's listed in the Thomas' Register.) For tube technical data, write RCA, Commercial Engineering, Section C-56-T 415 S. Fifth Street, Harrison, N. J.

RADIO CORPORATION of AMERICA
ELECTRON TUBES — HARRISON, N.J.

Write today for your free copy of this Technical Paper.

ask for data file **310**

Accuracy of Potentiometer Linearity Measurements

BY ROBERT MC DONALD & IRVING HOGAN

Research and Development Division
Helipot Corporation

Reprinted from TELE-TECH & ELECTRONIC INDUSTRIES

386

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California
a division of BECKMAN INSTRUMENTS, INC.

NEW ELECTRO SWITCH CATALOG



Low-cost, Dependable
ROTARY MULTIPOLE SWITCHES
for instrument, transfer, and selector service

ESCO instrument switches permit control of complex circuits with a single compact switch instead of separate switches. This catalog covers ESCO Types P snap-acting and Type JR detent-action switches.

Write today for your copy of this new catalog.

ELECTRO SWITCH
CORPORATION
Weymouth 88, Massachusetts

ABSTRACTS

able degree by physicians who have undergone shock treatment several times by way of experiment, with no apparent change in their capacities. The equipment depends on accurate pulse lengths and means for measuring the effectiveness of the electrodes' contact.

Massaging may involve the direct stimulation of nerves responsible for lung motion, although more conventional techniques will use pneumatic devices. A simple massager has a metal cup, with rounded edges, attached to pulsating vacuum source. Other machines extend limbs in a rhythmic routine.

A complete catalog of other medical mechanisms would extend many pages further, as would descriptions of apparatus used for testing temperature, blood oxygen content, velocity, and viscosity.

A Better Yardstick

From "Measuring Distances by Light Pulses," by A. G. Thomson, in "Instrument Practice," December 1954, London.

Using a rapidly rotating slotted whiil, Fizeau measured the speed of light. A distant mirror reflected light pulses going through the slots, and by viewing the mirror through an adjacent slot, the disk was speeded to the point where it had traveled one slot before the pulse of light returned from the mirror. A Swedish inventor, E. Bergstrand, has developed something called the geodimeter, which uses the known speed of light to measure the distance between the source and a mirror. With a quartz crystal oscillator pulse clock and an electromagnetic field shutter (rotating incoming light through a polaroid filter to produce shutter "openings") the time required for the passage of the light beam is measured in ten millionths of a second (meaning that the oscillator is operating at 10 megacycles). As the light requires 1/15,000 sec to travel 10 kilometers (6.21 miles) and back, more than 600 pulses have elapsed before the light pulse returns. Establishing the phase relationship between return pulse and adjacent generator pulses can yield high accuracy. Although the receiver is such a highly sensitive photocell that the geodimeter cannot be used even on moonlit nights, it should be valuable in the highly accurate measurement of substantial distances.

Integration A to Z

TREATISE ON INTEGRAL CALCULUS. *Joseph Edwards, Queen's College, London, 5 by 8 in., two volumes, 1,887 pp. Published by Chelsea Publishing Co., 552 West 181st Street, New York, N. Y. $6.50, each volume.*

This is a new edition of one of the most comprehensive treatments ever given a specific field of mathematics. The twin volumes, first published more than 30 years ago, were intended to be textbooks. But they can serve also as thorough reference works. They should be particularly handy for engineers who are unafraid of mathematics but who are slightly shaky on advanced techniques.

As its length suggests, the treatise covers all aspects of integration. It starts with a basic discussion of the nature of integration and methodically proceeds to cover the area of a first-year college course. From this point Professor Edwards soars into higher and higher mathematics: rectification through elliptic functions, rectification of twisted curves, Eulerian integrals, Lejeune-Dirilecht integrals, calculus of variations, Fourier series, applications to chance and error, harmonic analysis, and many other subjects.

The treatise is jammed with illustrative examples and problems (answers in the back) that make it useful for reviewing half-forgotten techniques and mastering unfamiliar ones.

While answering many questions, the volumes raise one: To what manner of students did Professor Edwards teach this mass of knowledge?

The Thinkers

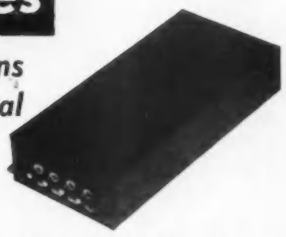
OPERATIONS RESEARCH FOR MANAGEMENT. *Edited by Joseph F. McCloskey and Florence N. Trefethen. 6 by 9 in., 409 pp. Published by The Johns Hopkins Press, Baltimore, Md. $7.50.*

Much of this book attempts to define a sometimes thing: something which, through its growth during the last war, changed from the application of common sense to the use of fairly advanced statistics.

War having changed during the last few centuries from a more or less leisurely blood bath to a smoking shower of high explosives, men in the thick of headquarters combat often lose

Brew Delay Lines

. . . for applications requiring exceptional characteristics



Shown above is a Lumped Constant Delay Line designed, manufactured, and *delivered on schedule* to a customer who came to us with the following requirements: delay 1.0 usec, reflections' 50 db below peak signal, frequency response: from 0-4.5mc less than ± 0.1 db — from 4.5-10mc less than ± 6 db, attenuation less than 6 db, phasing ± .01 usec 0-4.2 mc, impedance 150 ohms, max. temp. 150° F., operating temperature 120° F., voltage 350 VDC ± 6 VPP video, source impedance 4 uu 1200 ohm, grid circuit termination 10 uu.

The three main types of delay lines . . . Lumped Constant, Ultrasonic, Distributed Constant . . . are available from Richard D. Brew and Co., and our special techniques and methods, plus rigid quality control measures assure you of the finest and most practicable delay lines to meet your needs. Major consideration is given to proper packaging as well as electrical specifications.

Consult Richard D. Brew and Co. and you'll get enthusiastic cooperation and help.

Send for General Catalog 54

BREW

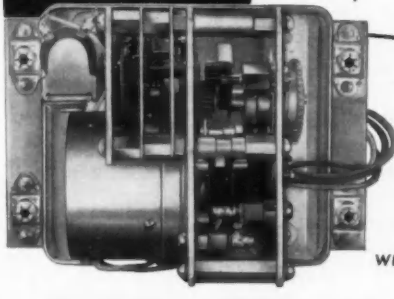
Richard D. Brew and Company, Inc.
Concord, New Hampshire
design · development · manufacture

There'd be no "blip" without power control by the

A.W. HAYDON COMPANY

*Blip — Reflected Radar Signal





This Time Delay Relay is used to delay application of plate power to vacuum tubes until filaments reach operating temperature. It provides maximum reset rate with minimum "time-out". — Eliminates danger of costly tube damage. — Provides *faster* response. Send for information about this Time Delay Relay and other special cost-saving timing devices.

double delayed reset time delay relay

WHEN TIMING POSES A PROBLEM CONSULT

The A.W. HAYDON COMPANY
246 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

from KDKA to RADAR! join the company that creates history in electronics!



now... you can CREATE with the WESTINGHOUSE electronics division

It's a long way from KDKA . . . the world's first radio broadcasting station . . . to radar, the backbone of America's air defense. It's a long way from the vacuum tube to the transistor.

To the men who have played vital roles in these developments . . . electronics has been a challenge. To you . . . it is an opportunity. It is the opportunity to **create** history in electronics, just as other engineers have done at Westinghouse.

Top-level design and development positions are now open. If you can fill one of these exciting openings . . . you will find unlimited creative opportunity. You will be well-compensated for your efforts . . . both in income and benefits, and in the satisfaction of contributing to America's superiority in ground and shipborne radar; fire-control, communications and missile guidance systems.

openings exist for:

Circuit Engineers
Radar Systems (Indicator) Engineers
Antenna Waveguide Engineers
Transformer Magentics Engineers
Digital Analog Tracking Specialists
Technical Writers

act now!
See us at the I.R.E. show
or
Send letter outlining education and experience to—

R. M. Swisher, Jr.
Employment Supervisor, Dept. 107
WESTINGHOUSE ELECTRIC CORP.
2519 Wilkens Avenue
Baltimore 3, Maryland

YOU CAN BE SURE...IF IT'S
Westinghouse

NEW BOOKS

sight of the obvious while concentrating on the fine hairs of precision destruction. Awareness of this caused individuals and groups to be formed under no instructions except to study a process and make recommendations for its improvement. The application of a little common sense to the many-dimensioned subtleties of war often yielded astonishing results. So much was the military impressed by the benefits of common sense, that study groups florished on all fronts by 1944, or, at least, they swarmed through all headquarters.

The groups tended to be motley lots—teachers, lawyers, biologists—simply because more suitable personnel wasn't available. Statistics turned out to be the most widely used tool, and probability the matter at hand. By the end of the war, "Operations Research" was very much the mathematician's baby. Questions on the effectiveness of bomb patterns from various altitudes, mine-seeding patterns, most effective ways of cutting supply channels, best maneuvering pattern for ships under attrack, in brief, any problem where there was no sure best technique, but only a probability that one was better than others. Using simple statistics and data taken from the field, many procedures were suggested that resulted in substantial improvements over past "guesswork" performances. Often the problems being studied required engineering knowledge to interpret data and state concrete proposals; or psychologists to obtain behavioral data and test the effectiveness of new procedures. The application of "common sense" to larger questions, such as logistics and procurement, soon involved concepts more sophisticated than simple statistics. With the end of the war, the Rand Corporation was created out of a former military operations research group, and many management consultant organizations saw the possibility of applying the "operations research", approach, with high mathematically connotations, to problems of marketing and sales.

This book attempts to give a broad picture of what is, has been, and may yet be operations research. Some aspects of machine design, of accounting, of sales and promotion are mentioned for their appropriateness to this way of thought. For control engineers, this subject should have some interest because it is an "integrating" philosophy.

When production systems are de-

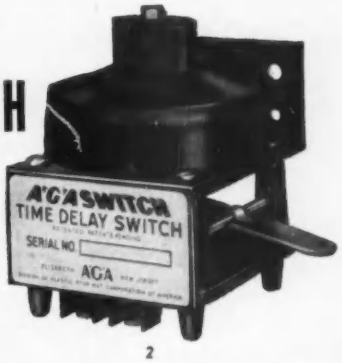
signed to use, as direct feedback, information on inventories and national economic conditions, people called "operations researchers" are almost sure to have a hand in setting up the communications.

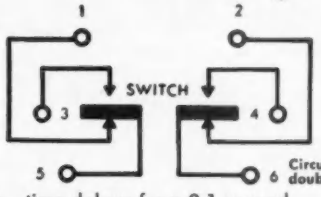
Each chapter of the book has a different author. The tie-in between the chapters is a little uneven. The chapter titled, "The Use of Computing Machines in Operations Research," is a fine piece of writing on the use and economics of large computers vs slower methods. There are some curves of mathematician vs machine for different-sized problems on a cost basis. However, the chapter fits into the book only by grace of the observation that, whenever appropriate, operations researchers should use computers.

The book is well organized. Part I talks about the history of operations research, its status, as a science, its future, and its present economic status. Part II, Methodolgy, contains the chapter on computers, plus "Queueing Theory," "Information Theory," "Symbolic Logis," "Game Theory," "Linear Programming," "Suboptimization," and "Statistics." Many of these are in the same fix as the chapter on computers. However, their quality is high, in terms of their ambitions. They start with the premise that the reader knows nothing about the subject, and they carry him to its highest applied level in round terms, often with the basic math and a brief historical rundown.

Part III consists of case histories. In every instance, the problem involved some operation with a large group of instances, sales, or performances. In some businesses, such as mail order houses, even small ones, a 1 per cent change in buyer performance might reduce or increase profit by 20 or 30 per cent. In operations involving a 100,000 men, shells, or bombs, a 3 per cent improvement in performance might quickly pay for the great deal of research required to make the change. This is, essentially, the crux of the operations researcher's sales line: any operation, where a small percentage change in performance will have considerable economic significance, can probably be analyzed for all the pertinent variables and one or another manipulated, even at an increase in cost for that particular operation, which will, however, improve the overall performance of the system. With very large and complex systems, some substantial math is involved.

NEW!
AGASWITCH
TRADEMARK
...to introduce time delays into electrical circuits





Circuit diagram, double pole unit

- Adjustable—time delays from 0.1 second to 5 or more minutes
- Manually operated, pneumatically timed
- Only 3½" x 2½" x 2½" overall
- Both single and double pole types
- Accurate, adaptable, compact and inexpensive

Write for details or application engineering assistance. Address Dept. A6-320.

AGA DIVISION
ELASTIC STOP NUT CORPORATION OF AMERICA
1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

New Ametron®



Compact
Sturdy
Economical

- Accumulates and records in printed form digital information
- Accepts pulses at rates up to 1000 CPM
- Prints on 2 inch wide tickets or standard 2¼ inch adding machine tape
- Automatic or manual reset available
- Both counting and printing circuits may be actuated by momentary closure of external contacts

Write for illustrated bulletin MD-44

STREETER-AMET COMPANY
4101 RAVENSWOOD AVENUE • CHICAGO 13, ILLINOIS
THE STANDARD OF ACCURACY SINCE 1888
Branches in Detroit, Pittsburgh, Allentown, Birmingham and Los Angeles

WHAT'S AHEAD: MEETINGS

FEBRUARY

Instrument Society of America, New York Section, (session on instrumentation for data reduction and presentation), Hotel Statler, New York, N. Y. Feb. 23

MARCH

American Institute of Electrical Engineers, Institute of Radio Engineers, Association for Computing Machinery, Western Computer Conference, Hotel Statler, Los Angeles, Calif. Mar. 1-3

Instrument Society of America, Pittsburgh Section, "Instrumentation in the Iron and Steel Industry," Hotel William Penn, Pittsburgh, Pa. Mar. 8-10

Institute of Radio Engineers, National Convention, Waldorf-Astoria and Kingsbridge Armory, New York, N. Y. Mar. 21-24

American Institute of Electrical Engineers, Materials Handling Conference, Hotel Cleveland, Cleveland, Ohio. Mar. 28-29

American Society of Metals, Ninth Western Metal Congress and Exposition, Ambassador Hotel and Pan American Auditorium, Los Angeles, Calif. Mar. 28-Apr. 1

APRIL

American Institute of Electrical Engineers, Southern District Meeting, St. Petersburg, Fla. Apr. 13-15

American Society of Mechanical Engineers, spring meeting, Lord Baltimore Hotel, Baltimore, Md. Apr. 18-20

Society of Automotive Engineers, Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and Hotel McAlpin, New York, N. Y. Apr. 18-21

MAY

American Institute of Electrical Engineers, Middle Eastern District Meeting, Columbus, Ohio. May 4-6

American Institute of Electrical Engineers, Electric Heating Conference. LaSalle Hotel, Chicago, Ill. May 10-11

EXCEPTIONAL OPPORTUNITIES FOR

HYDRAULIC & ELECTRONIC ENGINEERS

● Vickers steadily growing Aircraft Division offers unusual advantages to Engineers interested in Research, Development, Design, or Technical Sales. Applicants should have experience in one of the following:

Missile Controls
Jet Engine Controls
Constant Speed Drives
Servo-Mechanisms and Valves
Aircraft Hydraulic Systems and Controls

DESIGN ENGINEERS
Experienced product designers will find numerous benefits at Vickers . . . as will recent graduates with degrees in Mechanical, Aeronautical or Industrial Engineering.

RESEARCH AND DEVELOPMENT ENGINEERS
Experienced laboratory engineers and physicists will find distinctive advantages at Vickers.

TECHNICAL SALES ENGINEERS
Experienced Mechanical or Electrical Engineers who have sales ability and are willing to relocate after training are needed. Excellent opportunities also for recent graduates to train for hydraulics sales.

If you meet any of these qualifications, here is the opportunity of a lifetime. Mail resume of education, experience and personal qualifications to

VICKERS®
THE LEADING NAME IN
HYDRAULICS

Salaried Personnel Dept.
VICKERS Incorporated
DIVISION OF THE SPERRY CORP.
1400 OAKMAN BLVD.
DETROIT 32, MICH.

7131

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1927

PROFESSIONAL SERVICES

- RESEARCH
- TESTING
- MANAGEMENT
- ECONOMIC STUDIES
- INSTRUMENTATION
- CONTROL SYSTEMS
- DESIGN
- PATENTS



GEORGE H. BATEMAN
Engineering Services
Custom design of electronic devices for remote and automatic control using magnetic amplifiers, transistors and vacuum tubes.
Box 345 Grand Rapids, Michigan

ROGER BARRETT BROSS
Consulting Engineer
SPECIAL ELECTRIC MOTORS
ELECTROMAGNETIC COMPONENTS
Design - Development - Manufacture
Testing - Application
25 Curtis Rd OL 3-9235
Box 157, Natick, Mass.

HANSON-GORRILL-BRIAN INC.
Specialized Control Systems
ELECTRICAL - ELECTRONIC
HYDRAULIC - MECHANICAL
One Continental Hill Glen Cove, N. Y.
Glen Cove 4-7300

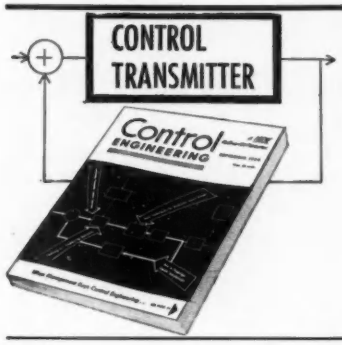
INTERFERENCE MEASUREMENT LABORATORY
Consulting—Research—Development
Interference Study per Government Specifications
Shielded Space for Interference Investigation
Radio Interference Filters
907 East 51st Street Brooklyn 3, New York
Ingersoll 9-1765

Attention

CONSULTING ENGINEERS

As you already know, the field of Control Engineering is growing by leaps and bounds throughout all industries. What you might not know is that many, many companies have actually scheduled big programs in instrumentation and automatic control for 1955. Many of these firms, out of necessity, will have to enlist the aid of a Consulting Engineer to solve problems that will arise resulting from this changeover.

By offering your specialized services through a professional card in this "Professional Services Section" of Control Engineering you will attract new clients. Cards are set in standard size and style as shown above. The rates for this service are extremely low. $35.00 per quarter on a six-month basis—and $30.00 per quarter on a twelve month basis. Bills are rendered each calendar quarter. Cash discount 2%-10th of the month following date of invoice. Send us your order for the next issue now.



The Classified Advertising Section of CONTROL ENGINEERING

EMPLOYMENT: "OPPORTUNITIES" :EQUIPMENT
BUSINESS: :USED OR RESALE

UNDISPLAYED —RATES— DISPLAYED

$1.50 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Position Wanted undisplayed rate is one-half of above rate, payable in advance.

Box Numbers count as one additional line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Equipment Wanted or For Sale Advertisements acceptable only in Displayed Style.

Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $14.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

New Ads Received by March 3rd at the New York office, 330 W. 42nd St., New York 36, N. Y., will appear in the April Issue subject to limitations of space available.

FOREIGN SERVICE
INSTRUMENT REPAIRMEN

Minimum 4 years' journeyman experience inspecting, testing and repairing modern flow, pressure and temperature instrumentation in petroleum or chemical processing plants.

RELAY TECHNICIANS

Qualified Journeyman Electrician with minimum 2 years' experience as a Relay Technician investigating and correcting power line circuit troubles caused by relay failures.

Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 97
ARABIAN AMERICAN OIL COMPANY
505 Park Avenue
New York 22, N. Y.

Engineers and Physicists
M.S.or Ph.D

Senior engineers and physicists with excellent grounding in fundamentals of both analytical and laboratory research and development are needed for new activities in computers, automatic controls, and electromechanical design.

Men with versatility and leadership ability will be offered the opportunity to develop research programs along the lines of their own experience and interest within the wide scope of activities possible in an independent organization.

Write

S. J. Keane, Physics Department
Southwest Research Institute
8500 Culebra Road San Antonio, Texas

INDUSTRIAL ELECTRONICS REPRESENTATIVES WANTED

Territories open to agents who know and can sell industrial electronic and automation controls. Young, aggressive company offers complete timer line, pilot relays, liquid level and special control devices. Please give territory wanted and experience. Details will be forwarded.

Ferrara, Inc.
8106 W. Nine Mile Rd. Oak Park 37, Mich.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (36)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)
LOS ANGELES: 1111 Wilshire Blvd. (17)

POSITION WANTED

PROFESSIONAL ENGINEER, consultant or automatic controls and office work automation applications has available consulting time. PW-5468, Control Engineering.

WANTED

ANYTHING within reason that is wanted in the field served by Control Engineering can be quickly located through bringing it to the attention of thousands of men whose interest is assured because this is the business paper they read.

Creative Engineering Opportunities with Republic

Research

Vibration Engineer

Two to five years aircraft vibration experience required. Shock and vibration theory and a practical knowledge of electromechanical shaker application as used in experimental research testing of complete airframes for flutter analyses and component investigation essential. Familiarity with usage of accessory electronic instrumentation equipment desired. Graduate with M.E. or A.E. degree preferred.

Please address complete resume, outlining details of your technical background, to:
Mr. R. L. Bortner
Administrative Engineer

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

DU PONT

offers a **CAREER OPPORTUNITY** *for an*

ENGINEER

in Chemical Process

AUTOMATIC CONTROL AND INSTRUMENTATION

Du Pont's Engineering Service Division, the Engineering Department's centralized consultant organization, has an unusual career opening in chemical process instrumentation for an experienced specialist with an educational background in engineering or physics.

The successful applicant will provide technical assistance and consulting service to operating plants and laboratories on instrument application, specification, and use for the measurement and automatic control of chemical processing variables, including temperature, humidity, fluid flow, liquid and solids level, pressure and vacuum, velocity, weight, force, torque, and electrical characteristics.

Appropriate experience will include installation, test, calibration, and operation of process instruments closely associated with the chemical industry. Duties of the position require responsible experience in and extensive knowledge of process dynamics and plant type analysis instrumentation employing electronic circuitry and based on physical principals, such as thermal conductivity, electrical conductivity, refractive index, infra-red absorption, etc.

Please send complete resume, including details of education and experience, to:

Mr. J. C. Costello, Jr.
Engineering Dept., Personnel Section
E. I. du Pont de Nemours & Co., Inc.
Wilmington 98, Delaware



do you know this man?

Here's his dossier: *Graduate Engineer, in his thirties. Lost in a large engineering group. Married, has good paying job but no future. Could go far with right opportunity for creative engineering work.*

If you know this man, tell him to communicate with J. M. Hollyday, Dept. E-3, The Glenn L. Martin Company, Baltimore 3, Maryland.

Subject: *Exciting new long range developments at Martin which have created many exceptional opportunities in Electronics and Servo-Mechanisms on projects of the highest priority and promise.*

P.S. He may be you.

You can contact Martin representative, Mr. Charles Heintz, at the Waldorf during the IRE conference.

MARTIN
BALTIMORE · MARYLAND

ARE YOU IN NEED

OF ENGINEERS or of HIGHLY TRAINED TECHNICIANS for your Personnel Program?

We offer a booklet especially prepared to help you solve this problem. It is called the "RESERVOIR of ENGINEERS and TECHNICAL MEN".

This booklet shows, through a listing of the major job titles held by readers of McGraw-Hill Publications, how these men are gathered in convenient, compact groups that you can economically reach with your advertising. Here are no huge, swollen circulations, with expensive price tags where maybe not one reader in a thousand would have the necessary job qualifications.

In a recent advertisement one of the leading aircraft manufacturers restated a well known, but seldom practiced principle:
A trained, experienced engineer in one specialty can be retrained in almost any other engineering specialty with a minimum of time and effort expanded.

It is one of the purposes of this booklet to show how you can best reach men specifically trained for your needs or technicians who can be easily and quickly retrained.

For your free copy of this booklet write us on your letterhead. You are under no obligation whatsoever. There is a limited supply so write us now.

McGraw-Hill Publishing Co., Inc.
Classified Advertising Division
330 West 42nd St., New York 36, N. Y.

ENGINEERS • *Electronic* • *Electromechanical*
PHYSICISTS
SALES ENGINEERS

Burroughs
Research Center, Paoli, Pa.

Invites You

To Inspect Its Openings on Both Commercial & Sponsored Projects!

Enjoy These Advantages!

In addition to paid vacations, liberal pension plans and numerous other valuable health and hospitalization benefits for you and your family, we provide cooperative educational aid at one of the many technical schools in the Philadelphia area for qualified applicants who find our center an ideal work-shop in which to secure the desired recognition in their chosen fields.

Your family, too, is important! And, here at Paoli, a delightful suburban community, thirty minutes from Philadelphia, you will find the cultural atmosphere as well as the educational facilities required for your children.

We will pay travel expenses for all applicants invited to visit our NEW Research Center to consider the application of their educational and/or work background to the many challenging problems we are engaged in for industry and the nation's welfare.

If you want the BEST for yourself and your family, consider NOW your qualifications for the openings listed on the right and —

Write **L. E. DICK**, *Personnel Manager*
BURROUGHS RESEARCH CENTER
Paoli, Pa.

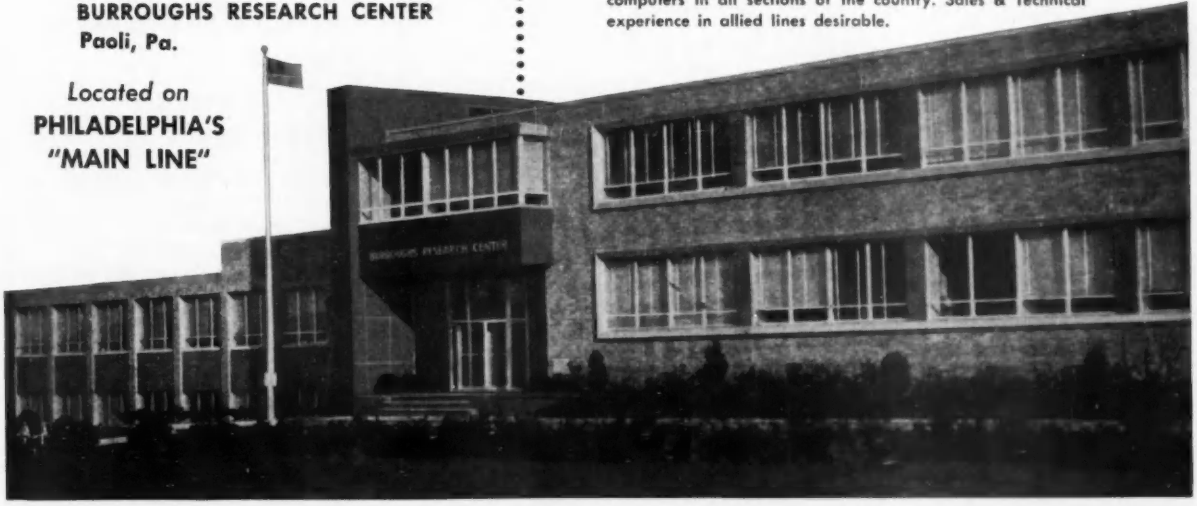
Located on
PHILADELPHIA'S "MAIN LINE"

If you possess an educational and/or work background in Communications, Data Handling, Electronic, or Electro-Mechanical Business Machines . . . including such specifics as High Speed Mechanisms, Paper Handling Devices, Magnetic-Tape Transport Mechanisms, Magnetic-Drum or Tape Applications, Radar, Telemetering, Guided Missiles, Process Control Instrumentation, Digital and Analog Computers, Transistor and Magnetic Circuit Design and Analysis, Magnetic Amplifiers, Servo Mechanisms, and Electronic Packaging Design . . .

CONSIDER THESE OPENINGS AS

- **ELECTRICAL ENGINEERS; Junior & Senior**
- **MECHANICAL ENGINEERS; Junior & Senior**
- **LOGICAL DESIGNERS • PHYSICISTS**
- **PROJECT ENGINEERS**

- **SALES ENGINEERS** to sell E-101 electronic desk computers in all sections of the country. Sales & Technical experience in allied lines desirable.





YOUR CALLING CARD FOR A BRILLIANT FUTURE...

Bendix Missile Section is a major contractor in the U. S. Navy's guided missile program--a part of the "new look" in our defense plan. Our expanding program has many opportunities for senior engineering personnel: Electronics Engineers, Dynamicists, Servo-Analysts, Stress Analysts, Project Coordinators, and Designers. Take time now to look into the opportunities which Bendix can offer you. Write Employment Dept. M, 401 Bendix Drive, South Bend, Indiana.

ENGINEERS

The APPLIED PHYSICS LABORATORY OF THE JOHNS HOPKINS UNIVERSITY offers an exceptional opportunity for professional advancement in a well-established laboratory with a reputation for the encouragement of individual responsibility and self-direction. Our program of

GUIDED MISSILE
DEVELOPMENT

provides such an opportunity for men qualified in:

ELECTRONIC CIRCUIT DESIGN AND ANALYSIS
DEVELOPMENT AND APPLICATION OF TRANSISTOR CIRCUITRY
SERVOMECHANISMS AND CONTROL SYSTEM ANALYSIS
ELECTRONIC EQUIPMENT PACKAGING
INSTRUMENT DESIGN
MISSILE SYSTEMS DEVELOPMENT
FLIGHT TESTING

Please send your resume to

Glover B. Mayfield
APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY
8621 Georgia Avenue
Silver Spring, Maryland

Engineers—
DESIGNERS-DRAFTSMEN
Electronic and Mechanical

"You just can't hardly find them no more"



OPPORTUNITIES like those now available at Melpar are difficult to find. Melpar, leader in electronic research and development, offers unlimited opportunities for personal advancement . . . unexcelled laboratory facilities at its new plant . . . diversified and challenging projects . . . long-range military and industrial program . . . and a new way of life in pleasant suburban Fairfax County in northern Virginia. Yes, "you just can't hardly find opportunities like them no more."

New positions created by our expansion require men with experience in the following fields:

- Network Theory
- Microwave Technique
- UHF, VHF or SHF Receivers
- Analog Computers
- Digital Computers
- Magnetic Tape Handling Equipment
- Radar and Countermeasures
- Packaging Electronic Equipment
- Pulse Circuitry
- Microwave Filters
- Flight Simulators
- Servomechanisms
- Electro-Mechanical Design

For personal interview send resume to
Technical Personnel Representative,

melpar, inc.
Subsidiary of Westinghouse Air Brake Co.
3000 Arlington Blvd., Dept. CE-7
Falls Church, Virginia
or 11 Galen St., Watertown, Mass.

ENGINEERS
AUTOMATION CONTROLS & INSTRUMENTATION

- Industrial Process Instrumentation
- Hydraulic or Pneumatic Controls
- Electrical Controls
- Servomechanisms
- Machine Design

Training or experience in one or more of the above fields may qualify you for unusual opportunities for individual development and advancement in automation. Wide variety of work and challenging problems in the design of advanced test facilities and industrial installations.

Please write fully to—

SVERDRUP & PARCEL, INC.
Consulting Engineers
915 Olive St. Louis 1, Mo.

ENGINEERS

ELECTRONIC AND ELECTRO-MECHANICAL DESIGN

BSEE with at least two years specialized experience. Essential qualifications are abilities and experience in electronic and/or electro-mechanical systems engineering with emphasis on amplifiers, telemetering and computers. Salary commensurate with experience. Top-notch employee benefits. Location San Francisco Peninsula.

DALMO VICTOR COMPANY
1414 El Camino Real San Carlos, Calif.

EMPLOYMENT PROBLEM?

When you are in need of specialized men for specialized jobs, contact them through a *classified ad* in a McGraw-Hill Publication.

Management, Engineering, Production, Maintenance, Selling . . . these represent broadly the principal functions in business and industry. And it is principally to the men and executives who fill key jobs in these important divisions that McGraw-Hill publications are directed.

McGraw-Hill Domestic Publications

AMERICAN MACHINIST
AVIATION WEEK
BUS TRANSPORTATION
BUSINESS WEEK
CHEMICAL ENGINEERING
CHEMICAL WEEK
COAL AGE
CONTROL ENGINEERING
CONSTRUCTION METHODS AND EQUIPMENT
ELECTRICAL CONSTRUCTION AND MAINTENANCE
ELECTRICAL MERCHANDISING
ELECTRICAL WHOLESALING
ELECTRICAL WORLD
ELECTRONICS
ENGINEERING AND MINING JOURNAL
ENGINEERING NEWS-RECORD
FACTORY MANAGEMENT AND MAINTENANCE
FLEET OWNER
FOOD ENGINEERING
NATIONAL PETROLEUM NEWS
NUCLEONICS
PETROLEUM PROCESSING
POWER
PRODUCT ENGINEERING
TEXTILE WORLD

THE MEN YOU NEED ARE THE MEN WHO READ THE

McGRAW-HILL PUBLICATIONS
330 West 42nd St.,
New York 36, N. Y.

IMMEDIATE DELIVERY
PRODUCTION QUANTITIES

ALLIED LEACH GUARDIAN

RELAYS

MIN. AIRCRAFT And Many Others TELEPHONE TYPE

WESTON TYPE 705 SENSITROL
15,800 NOW IN STOCK!



#R561

Operation is as follows: The stationary contact is a small powerful permanent magnet and movable contact is iron "rider" mounted on pointer which travels over relay scale. Operating torque moves pointer into magnetic field of stationary contact. This contact then draws movable contact and holds it firmly. Perfect contact is assured and chattering is eliminated. Contacts remain closed until reset. Accuracy in general may be considered as within 5% of the range. Operates directly from a photocell or a group of thermocouples. Net weight 14 oz.

Double contact with Solenoid Reset; Sensitivity 7.5 Microamps; Reset coil 6-24 VDC or 24 VAC; Makes contact on increasing or decreasing values; Contacts: "Twintacts", Capacity 100 ma at 110 volts; Nickel plated, Brass cover; Weston Model 705 Type 6 #R560 ..... **18.75**
10 for $170.00

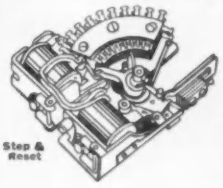
Same as #R560 but with glass face; Weston Model 705 Type 6 #R561..... **19.75**
10 for $180.00

Single contact (Normally Open), Solenoid Reset; Sensitivity: 10 Microamperes; Reset coil; 6-24 V DC or 24 V AC; Contact: "Twintact", capacity 100 ma at 110 volts; Glass Face: Weston Model 705 Type 4 #R523. **17.75**
10 for $160.00

Same as #R523 with Brass Cover Weston Model 705 Type 4 #R523N..... **16.75**
10 for $150.00

Production Quantities Available. Call Us for Prices.

STEPPING SWITCHES



Step & Reset

Mfg by Western Electric, Automatic Electric Sales
Minor Switch 10 steps and off Contacts: Gold plated brass; Bridging Wiper; Operating Voltage 6.0 to 12.0 V. DC Net Weight: 1 lb.

SS5	Each	Lots of 10
#R960; Single Level; 6 to 12 VDC.	10.95	9.00
#R975; Single Level; 24 to 36 VDC.	11.95	10.00
#R976; Single Level; 48 to 60 VDC.	12.95	11.00
#R977; Two Level; 6 to 12 VDC.	12.95	11.00
#R978; Two Level; 24 to 36 VDC.	13.95	12.00
#R979; Two Level; 48 to 60 VDC.	14.95	13.00



Mfg. by Western Electric Co., Automatic Electric Sales; 22 step; 5 levels; Bridging Wipers; Contacts: Gold plated brass
Interrupter Switch: 1 Break-Make; Net Weight: 2 lb. 2 oz.

SS6 "Homing" Type; Double-Ended Wipers; Step in One Direction

#R926; 6 to 12 VDC.....	14.75	12.00
#R980; 24 to 36 VDC.....	15.75	13.00
#R981; 48 to 60 VDC.....	16.75	14.00

Mfg by Western Electric Co., Automatic Electric Sales; 44 step; 2 levels; Bridging Wipers; Contacts: Gold plated brass; Interrupter Switch: 1 Break-Make; Net Weight: 1 lb. 14 oz.

SS7 "Homing" Type; Double-Ended Wipers; Step in One Direction

#R927; 6 to 12 VDC.....	14.75	12.00
#R982; 24 to 36 VDC.....	15.75	13.00
#R983; 48 to 60 VDC.....	16.75	14.00

SEND FOR COMPLETE CATALOG

TERMS:—All Prices F.O.B. Our Plant. Rated Firms Net 10 Days; All Others Remittance with Order. Orders Under $10 Remittance With Order, Plus Approximate Shipping Charges (overage will be returned.)

Cable Address: UNIGENCOR, N. Y.

324 CANAL ST., N.Y.C., 13, N.Y. WAlker 5-9642
Universal general corp.



ENGINEERS . . .

You'll measure up to your fullest potential

with

Westinghouse

at the ELECTRONIC TUBE DIVISION in Elmira, New York

Based on your abilities for achievement, you can't help but progress, financially and professionally, along with the phenomenal growth and leadership of Westinghouse. And Elmira, amid upper N. Y. state's resort lakeland is a pleasant place to live . . . good schools, homes, every recreational facility.

Openings for:

DESIGN, DEVELOPMENT, and APPLICATION ENGINEERS: Receiving, image orthicon or vidicon tubes; solid state devices.

MICRO-WAVE TUBE DESIGN ENGINEERS: 2 or more years experience, for designing magnetrons, traveling-wave tubes, TR and ATR tubes, reference cavities, etc.

Above openings are for Engineers and Physicists with Bachelor's, Master's, or Doctor's degree. Also . . .

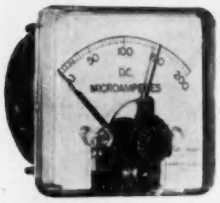
ELECTRICAL ENGINEERS, for EQUIPMENT DESIGN: designing, costing, and guiding construction of processing and testing equipment, e.g. atmosphere furnaces, electrical welders, induction heaters, X-ray seasoning and test units, waveguide apparatus, transistor life test units.

Interviews arranged in your area, or travel expenses paid if invited to Elmira for interview. Send resume:

WESTINGHOUSE Electronic Tube Division, P.O. Box 284, Elmira, N. Y.

METER-RELAYS

For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes.....Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc.

These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 22, Ohio.

Booth 311, I.R.E. Show, March 21-24

RECORA *Switchmat* ® T. M. REG



. . . thin, mat-like pressure switches that close circuits whenever pressure is applied to any point in their area; open circuits when pressure is released. Widely used as "area switches" on floors and platforms for automatic door openers, alarm systems, traffic controls etc. Used around machinery for foot switches, safety stations and emergency cut-outs. Available in any size, shape or quantity, for integral, built-in parts of mechanisms, devices and systems.

Operate at pressures from few ounces up, on low voltage, directly connected or through relays. Hermetically sealed between sheets of wear, acid and oil resistant vinyl plastic. Standard units, or to your specifications. Technical service supplied; just send us your switch problems.

Catalog Sheet CS—describing Recora Switches and control accessories sent upon request.



the RECORA Co.

51 W. 103RD STREET · CHICAGO 28, ILLINOIS

Advertising In This Issue

A

AGA Div. Elastic Stop Nut Corp. of America 129
Aircraft Marine Prod., Inc..... 25
American Gyro Div. of Daystrom Pacific Corp. 31
American Time Products, Inc... 97
Assembly Products, Inc.....98, 136

B

Bailey Meter Co..... 22
Brew & Co., Inc., Richard D... 127

C

Char-Lynn Co. 123
Cinema Engineering Co. 124
Comar Electric Co..... 8
Consolidated Engineering Corp. Systems Div. 36
Control Engineering..... 33
Control Engineering Corp..... 38
Cutler-Hammer, Inc. 79

D

Daystrom Potentiometer Div. of Daystrom Pacific Corp..... 101
Denison Engineering Co., The..28, 29
Diehl Mfg. Co..... 114
DuMont Laboratories, Inc., Allen B., Instrument Division..... 26

E

Electro Switch Corp..... 126

F

Fairchild Camera & Instrument Corp., Potentiometer Div..... 10
Fielden Instrument Div., Robertshaw-Fulton Controls Co..... 7
Fischer & Porter Co...Fourth Cover
Ford Instrument Co., Div. of The Sperry Corp..... 106
Fusite Corp., The..... 117

G

General Controls..... 32
Giannini & Co., Inc., G. M..... 6
Goodyear Aircraft Corp..... 1
Guardian Electric Mfg. Co..... 35

H

Hammel-Dahl Co. 80
Hammarlund Mfg. Co., Inc..... 2
Haydon Co., The A. W..... 127
Helipot Corp. Div. Beckman Instruments, Inc. 126
Hughes Research and Development Laboratories 100

I

Indiana Steel Products Co., The. 84
International Business Machines. 118

K

Kearfott Co., Inc..... 104
Kellogg Switchboard & Supply Co. 121
Kemp Mfg. Co., The C. M..... 21
Kendall Controls Corp..... 23
Kepco Laboratories..... 15
Kybernetes Corp., The..... 19

L

Lapp Insulator Co., Inc..... 27
Leslie Co. 88
Librascope, Inc. .....Second Cover

M

Magnetic Amplifiers, Inc..... 113
Manning, Maxwell & Moore, Inc. 24, 86
Master Electric Co., The..... 17
McGraw-Hill Book Co., Inc..... 122
Moseley Co., F. L..... 108

N

North American Instruments, Inc. 98
North Electric Mfg. Co., The... 112

P

Pathon Manufacturing Co..... 4
Perkin-Elmer Corp. Vernistat Div. 109
Polytechnic Research & Development Co., Inc..... 115

R

Radio Corp. of America Electron Tubes Div. 125
Recora Co., The..... 136
Revere Copper & Brass, Inc..... 103
Roller-Smith Corp. 82

S

Servo Corp. of America..... 102
Sigma Instruments, Inc. 107
Sola Electric Co..... 30
Sorensen & Co., Inc..... 110
Statham Laboratories 96
Streeter-Amet Co. 129
Superior Electric Co., The..... 99
Sylvania Electric Products Inc. 5

T

Taller & Cooper, Inc..... 105
Technical Charts Inc..... 124
Technology Instrument Corp. .....Third Cover
Thermo Electric Co., Inc..... 116
Thermo Electric Mfg. Co. 94
Tomkins-Johnson Co., The..... 111

U

U. S. Gauge Div. of American Machine & Metals, Inc..... 9

V

Valvair Corporation..... 40
Vard, Inc. 93, 95
Vickers Inc., Div. of Sperry Corp. 130
Victor Equipment Co. 123

W

Westinghouse Electric Corp..... 128

•

PROFESSIONAL SERVICES 130

•

CONTROL TRANSMITTER

(Classified Advertising Section)
H. E. Hilty, Mgr.

EMPLOYMENT
Positions Vacant 131-135
Positions Wanted 131

EQUIPMENT
(Used or Surplus New)
For Sale 135

ADVERTISERS INDEX

Arabian American Oil Co..... 131
Bendix Products Division Bendix Aviation Corp..... 134
Burroughs Research Center..... 133
Dalmo Victor Co..... 135
DuPont de Nemours & Co., Inc..... 131
Ferrara, Inc. 131
Johns Hopkins University..... 134
Martin Co., The Glenn L..... 132
Melpar Inc. 134
Republic Aviation Corp..... 131
Southwest Research Institute..... 131
Sverdrup & Parcel Inc..... 134
Universal General Corp..... 135
Westinghouse Electronic Tube Div.... 135

®

PRECISION POTENTIOMETER HANDBOOK AND CATALOG

a fact packed addition to your design bookshelf

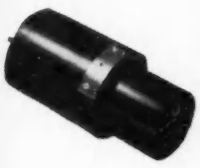


An authoritative engineering text covering the principles underlying the design and use of precision potentiometers has been prepared by TIC as an informational guide for you. This handbook of material is bound with a complete catalog giving specifications for all standard TIC potentiometers and test instruments.

You can familiarize yourself with accepted potentiometer terminology, circuits for potentiometer adjustment, non-linear loading techniques, resolution standards, causes of residual noise, and potentiometer design and construction features. This material is covered in the following chapters:

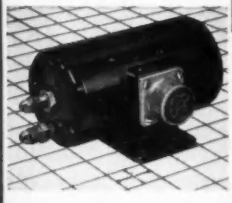
- Elements of a precision potentiometer
- Potentiometer terms
- Linearity
- Non-linear conformity
- Resolution and residual noise
- Operational characteristics
- Special designs
- Linear functions
- Non-linear functions by contoured resistance elements
- Non-linear functions by loading, clamping and ganging
- Mounting and ganging
- Bibliography

With this beautifully bound, flexible cover, loose-leaf book is provided a continuing subscription service, consisting of up-to-the-minute information on new developments in potentiometer technology and TIC models as they are introduced.



DIELECTRIC POTENTIOMETER

For broad band applications up to 10 mc., the PD-2 Dielectric Potentiometer uses variable capacitor electrodes immersed in a lossy liquid dielectric. Loss is independent of frequency, phase shift is zero. Total attenuation range is 25 db., resolution is infinite, a wide range of input impedance is available, and adaptation to specific non-linear functions or mechanical drive can be supplied. Inquiries on specific applicatons are invited.

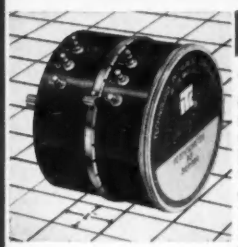


PRESSURE TRANSDUCER

This dual element air flow differential pressure transducer is designed for speed-altitude measurement in the ranges 0-580 knots, and −1000 to 20,000 feet, or similar applications. Double pairs of precision potentiometers are actuated by pressure response of static and dynamic bellows. Resistance ratios vs. pressure is linear within 0.5%, hysteresis within 0.5%, resolution increment is less than 0.2% of pressure range, withstands 10g of vibration up to 200 cycles, and 40g of shock.

®

continues to SET STANDARDS with NEW ADDITIONS to the PRECISION POTENTIOMETER FAMILY



LOW COST PRECISION POTENTIOMETERS

The "P" series is a low cost line especially appropriate for automation and industrial electronic test equipment. These units retain many precision features developed for stringent military requirements and feature TIC standards of accuracy, long life, low noise, and low torque. Available in linear or non-linear function. Bakelite cups instead of metal contribute higher breakdown voltage and insulation resistance, and lower distributed capacity. Type P1 ¼: 100 to 100K ohms, 0.75% linearity — Type P1 ⅜: 100 to 150K ohms, 0.3% linearity — Type P3: 100 to 200K ohms, 0.15% linearity.



ST09 MINIATURE POTENTIOMETER

This is a miniature precision potentiometer of the standard line. Only ⅞ of an inch in diameter, this new addition, built to military specifications, incorporates the precision TIC features: Independent linearity 1% of total resistance, standard, or 0.3% on special models; resistance range 100 to 50K ohms; electrical rotation 320° ±5° with special angles and closer tolerances available; torque 0.5 oz. in. standard, 0.1 oz. in. special; power rating 2 watts. Available in linear and non-linear functions.



MULTITURN POTENTIOMETER

The M10T servo wound Multiturn Potentiometer combines extraordinary mechanical precision and high electrical accuracy at lower cost. Independent linearity 0.05% standard, 0.025 or better in special units — resistance range 1000 ohms to 10,000 ohms ±5% — effective electrical angle: 3600° +1° −0° — one piece machined aluminum base, spring loaded ball bearings — mechanical rotation 3660° ±2.5° — stops withstand 100 pound-inch torque — starting torque 1.3 oz. in. — stainless steel cover.

Write Technology Instrument Corp. how to obtain the Potentiometer Handbook subscription service and the recent additions to the TIC line of potentiometers.

See Us At Booth 226-228
Instruments Avenue At The IRE Show

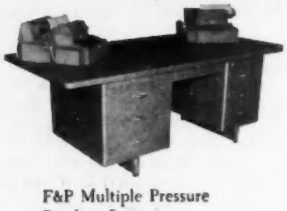
TECHNOLOGY INSTRUMENT CORP.

523 MAIN ST., ACTON, MASS. COlonial 3-7711
West Coast Mail Address P.O. Box 3941 North Hollywood, Calif. POplar 5-8620



Read your own Five Star Final on as many as 200 pressure measurements *in seconds* with the Fischer & Porter Multiple Pressure Readout System.

Yes, no matter how many pressures must be measured, recorded and processed—F&P hands you the headline news automatically with the F&P Multiple Pressure Readout System.



F&P Multiple Pressure Readout System

This unit simultaneously senses as many as 200 pressures with accuracies to one part in 2,000 or better, and produces not only typed tabulated lists of all pressures measured, but also places the information on a punched tape for feeding into a digital computing device. And it can repeat the cycle up to 120 times per hour.

F&P Data Processing Systems can save you much equipment, many man hours and can eliminate time lag when large quantities of process or test variables must be sensed, tabulated and interpreted.

Write today for full information without obligation.

complete process instrumentation

FISCHER & PORTER CO.

735 County Line Road, Hatboro, Penna.

MEASURING, RECORDING AND CONTROLLING INSTRUMENTS • CONTROL PANELS • DATA REDUCTION AND AUTOMATION SYSTEMS
CONTRACT INSTRUMENTATION RESEARCH • CHLORINATION EQUIPMENT • INDUSTRIAL GLASS PRODUCTS LA 1029